Tanyard Branch Watershed Management Plan

Performed for the Town of Easton, Maryland

Prepared by **Midshore Riverkeeper Conservancy** *and*

Center for Environment and Society at Washington College

with photos by **Aloft Aerial Photography**

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1.0 Executive Summary

Washington College Center for Environment and Society (CES) and Midshore Riverkeeper Conservancy (MRC) were contracted by the Town of Easton to perform a watershed assessment and plan for Tanyard Branch. Washington College's Geographic Information Systems (GIS) lab conducted a review of GIS base layers and provided detailed land use analysis, including newly mapped storm water infrastructure in this highly urbanized watershed. Both CES and MRC conducted extensive water quality monitoring for this project. MRC conducted pollution source analyses, neighborhood by neighborhood assessments, stormwater loading analyses, and retrofit and pollution remediation investigation and design.

Tanyard Branch is a heavily urbanized and impacted stream system. The total land area within the watershed is 911 acres. There are 1,200 residential units and 774 commercial units in the watershed. Impervious coverage of the watershed is 36%. The impervious area is broken down into 109 acres of parking lot, 92 acres of buildings and another 92 acres are comprised of roads. As the Town of Easton grew, Tanyard Branch was impacted by stream channelization, wetland loss, loss of stream side vegetated buffers, development in the floodplain, and stream burial which directed Tanyard Branch into pipes between Aurora Street and Easton Utilities. The high percentage of impervious coverage in the watershed has caused severe degradation to the stream and contributes high loads of nitrogen and phosphorus.

Watershed scientists have been able to correlate stream health with the percentage of impervious coverage since the early 1990's. The combination of wetlands loss, increased impervious coverage, and a robust storm drain network has altered the characteristics of the stream such that Tanyard Branch now acts more like a conveyance of stormwater rather than a healthy, functioning natural stream. Baseflow in the stream averages 0.51 cubic feet per second (cfs). Streamflow during storm events is exponentially higher. As an example, a half-inch rain event averaged 85 cfs (160 times base flow). This reveals that the stream is disconnected from its floodplain, has been channelized, piped underground, and is highly developed.

The following quote from the Center for Watershed Protection characterizes streams with impervious coverage greater than 25%.

"Once watershed impervious cover exceeds 25%, stream quality crosses a second threshold. Streams in this category essentially become conduits for conveying stormwater flows, and can no longer support a diverse stream community. The stream channel becomes highly unstable, and many stream reaches experience severe widening, downcutting, and streambank erosion. Pool and riffle structure needed to sustain fish is diminished or eliminated and the substrate can no longer provide habitat for aquatic insects, or spawning areas for fish. Water quality is consistently rated as fair to poor, and water recreation is no longer possible due to the presence of high bacterial levels…The biological quality of non-supporting streams is generally considered poor, and is dominated by pollution tolerant insects and fish."

Faced with the urban characteristics of Tanyard Branch, we recognize the impracticality of totally overhauling and remaking the stream, restoring a natural channel, creating natural buffers and developing drainage areas throughout that capture and slow runoff to mimic an undeveloped tributary. However, there are retrofits that we can implement that are both economical and effective in reducing and capturing nutrients and sediments before they enter the stream and helping to reduce loading at the stream's outlet to the Tred Avon River. We can slow water after rain events, and we can do much to improve the biological potential of the ponds that lie within the stream's path.

Routine water quality monitoring revealed good to fair water quality conditions for dissolved oxygen (DO) and nitrogen (TN), but elevated phosphorus (TP) (Section 3.4). Throughout the year we noticed blooms of filamentous algae in stormwater ponds within the watershed and within Tanyard Branch. The presence of large mats of algae throughout the stream indicates an abundance of nutrients moving through the system and that the stream is over-enriched.

From the estimated annual loadings based on our sampling, models were run in order to estimate what sectors produced the largest amount of nutrient inputs into the system. Phosphorus was modeled, but modeled results did not approximate measured loadings. This is not unusual as phosphorus is inherently more difficult to model accurately. Because of the difficulties calculating phosphorus reductions, we relate our retrofits to nitrogen reductions as these were accurately modeled, are more amenable to calculate, and can be easily tracked. In addition there is a keen interest in the TMDL process in reducing nitrogen loads. By referencing our retrofits to nitrogen reductions, we can also be assured that we will gain from those retrofits commensurate reductions in phosphorus, both improving the overall health of the stream and assisting the town in reaching TMDL nitrogen reduction goals. In other words, these retrofits will reduce both phosphorus and nitrogen loads simultaneously.

From our modeling it is clear that the largest sources of nitrogen to the Tanyard Branch are commercial areas, roads, and parking lots . From this information retrofits were identified that were near these areas. We have identified a suite of 67 Best Management Practices (BMP's) that, if implemented, have the capability to reduce the pollution loads to the Tanyard Branch by approximately 2,700 pounds of nitrogen per year. We are also recommending an education and outreach program that includes a rain barrel and rain garden program to reduce stormwater flows from residential neighborhoods.

The recommended BMP's are spread throughout the Tanyard Branch watershed and are an effort to restore natural processes of landscape features that have been lost due to urbanization. We have provided illustrations and descriptions of each BMP (see Appendix Section 10.2, Section 10.3). We have also developed cost estimates for each project and have prioritized each practice as "priority"1," "2," or "3,"with "1" being the highest. This priority is based on a cost/benefit analysis of the achievable load reductions, the importance of the retrofit to watershed health, and the practical ability to implement a given project.

The projected cost to implement all of the 67 BMP's is between $640,410 and $1,341,450 depending on the contractors and final design of the projects.

Because the impacts to the stream have occurred over hundreds of years in a piecemeal manner, the solutions to the problems are going to take time. Our prioritized list of retrofits identifies projects that cumulatively will slow and filter the flow of stormwater to Tanyard Branch in rain events. Our two top priority projects would physically remove nutrients from the waterway itself and could reduce the nutrient loading to the Tred Avon River by 1,000 pounds of nitrogen per year.

2.0 Introduction

The Tanyard Branch, located in Easton, Talbot County, MD, is a 911 acre watershed that drains into the Tred Avon River (Figure 1), a tributary of the Choptank River. The Center for Environment and Society (CES) and the GIS Program at Washington College, in partnership with the Midshore Riverkeeper Conservancy, have assessed and compiled available GIS data, conducted assessments of residential neighborhoods, stream corridors, and commercial and publicly owned properties. In addition we conducted extensive dry and wet weather water quality monitoring. We also used data generated by the GIS program to populate models to calculate nutrient loads to Tanyard Branch.

The results of these efforts were used to develop an extensive list of retrofit strategies, which, if implemented, could result in a 32% reduction in nitrogen loading to Tanyard Branch. The restoration strategies were also provided to assist the Town of Easton to effect measureable reductions in nutrients to the Tanyard Branch and the Tred Avon River.

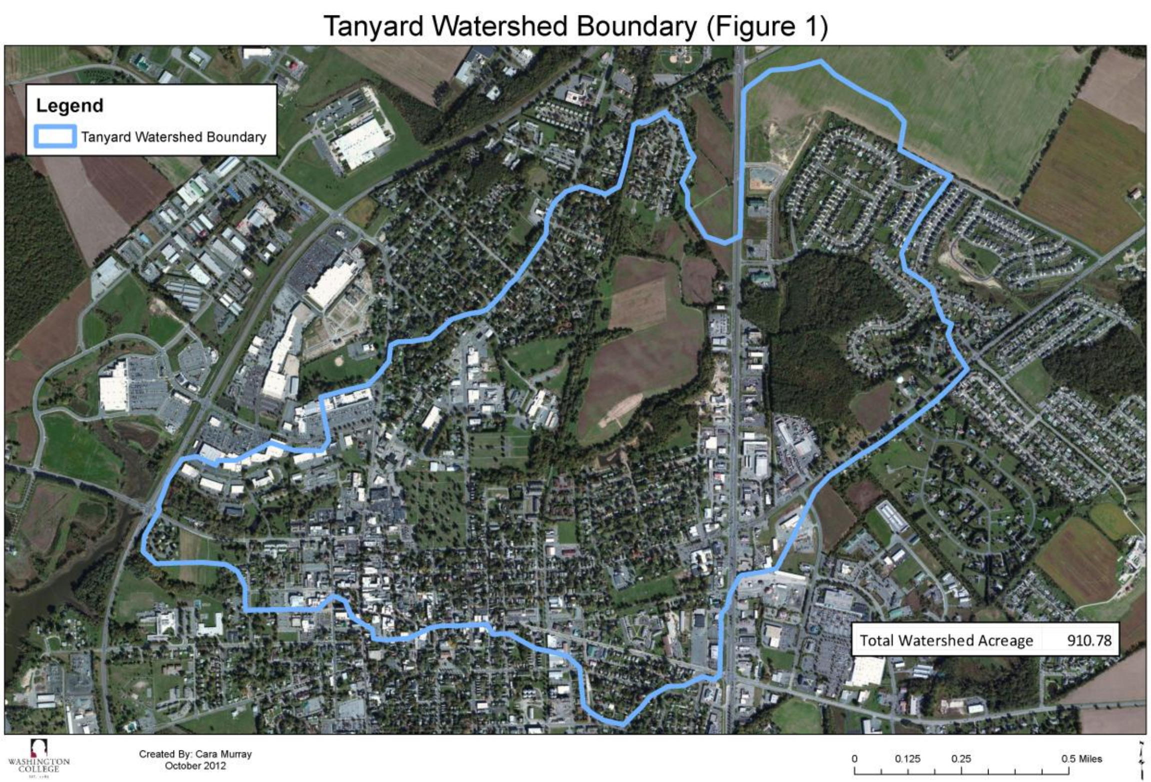


Figure 1: Overview of Tanyard Branch Watershed

This project had the following objectives:

1. Identify and prioritize sites throughout the study area that contribute high sediment, nutrient and anthropogenic pollutant loads to the receiving basin.

2. Identify and prioritize potential solutions and quantify nutrient reductions.

3. Identify watershed restoration project cooperators, approximate financial costs and prepare an implementation schedule.

The Tanyard Branch watershed planning project involved:

- A review of existing conditions and an analysis of nutrient contribution to the Tanyard Branch.
- The creation of a series of maps illustrating conditions and attributes of this watershed.
- Integration and analysis of existing water quality data for this watershed.
- Water quality monitoring during base and storm-flow conditions.
- Development of a watershed plan to improve water quality in the Tanyard Branch.
- An educational component to enhance public understanding and participation.

Our efforts have resulted in:

- Identification of causes and sources that need to be controlled to achieve load reductions.
- Estimation of load reductions expected for the management measures.
- Proposed management measures needed to achieve the load reductions.
- Proposed technical and financial assistance to implement this plan.
- Creation of a blueprint for implementing management measures.
- Proposed interim, measurable milestones for determining control actions.
- Monitoring criteria that measure the effectiveness of the implementation.

In this report we present a suite of retrofit projects that, if implemented, will achieve significant load reductions to receiving waters.

3.0 Methods and Results

3.1 Geographic Information System Analysis

The GIS Program at the Center for Environment and Society provided a comprehensive GIS analysis of the Tanyard Branch watershed. Mr. Stewart Bruce, GIS Program Coordinator, and Ms. Erica McMaster, GIS Project Manager, supervised a large team of qualified student interns to accomplish this work.

The team developed the original GIS data layers as well as collected existing GIS data layers that were clipped to the watershed boundary for analysis. GIS data are being delivered in an ArcGIS Geodatabase format with associated map documents suitable for display of the data. The following is a list of maps and analysis produced for the project and these can be found in Appendix 10.1.

<u>Figure 1: Watershed Boundary</u>

This map shows the outline of the watershed boundary which is calculated to contain 910.78 acres.

<u>Figure 2: Digital Elevation Model (DEM)</u>

To complete this analysis the 1/9 Arc Second DEM USGS (3 meter resolution) data was utilized and clipped to the Tanyard Watershed Boundary. The vertical accuracy of this data is +/- 8 inches and is a derivative product of the LIDAR data acquired by the Maryland Department of Natural Resources. The low elevation was 0.05 meters and the highest point was 24.55 meters

<u>Figure 3: Watershed Delineation</u>

Using the GIS data from DEM found in Figure 2, this data was then converted to a flow length map using ArcMap tools. By examining the hydrologic flow lines from the origination point the outline of the watershed boundary was traced. To assist in the delineation of this analysis, the Tanyard Stormwater System was added to this map so it could be seen where manmade stormwater lines impacted the natural flow of water. The boundary was adjusted accordingly.

<u>Figure 4: Tree Canopy</u>

This layer was digitized by a using a visual assessment of aerial imagery from several sources such as county imagery from 2004 and 2008, and Near IR imagery from USDA NAIP, along with multispectral imagery from Digital Globe WorldView II. The tree canopy coverage was attributed to be one of three types: deciduous, evergreen or mixed. Once the digitizing was complete, the data was clipped to the Tanyard Branch Watershed Boundary; then each type of canopy coverage was analyzed to determine acreage and percentage of watershed covered.

<u>Figure 5: Impervious Surface</u>

The impervious surfaces layer was digitized using a visual assessment of the aerial imagery, and was classified into eight separate categories. Once the digitizing was complete, the data was clipped to the Tanyard Branch Watershed Boundary; then each type of impervious surface was analyzed to determine acreage and percentage of watershed covered.

Figure 6: Building Outlines

The Talbot County GIS Buildings data were clipped to the Tanyard Watershed Boundary. The data was then divided into three types: commercial, no building and residential. The building land cover was then analyzed by determining the amount of acres covered by each type of building and then using that statistic to determine the percentage of watershed those types of buildings covered.

Figure 7: Land Use – Parcels

Using GIS data obtained from Talbot County the parcels were classified into ten categories. The data was clipped to the Tanyard Branch Watershed Boundary and then each type of parcel was analyzed to determine acreage and percentage of watershed covered.

Figure 8: Land Use – Structures

Using the parcel data obtained from Talbot County as a base map the staff utilized the American Planning Association Land Based Classification Standard to classify each parcel for Activity, Function, Structure, Site, and Ownership. This map shows the structure analysis.

Figure 9: Aspect

To determine Aspect the staff utilized 1/9 Arc second DEM USGS (3 meter resolution) data clipped to the Tanyard Watershed Boundary. The DEM data was then converted to an aspect analysis using ArcMap tools.

Figure 10: Slope

To determine Slope the staff utilized 1/9 Arc second DEM USGS (3 meter resolution) data clipped to the Tanyard Watershed Boundary. The DEM data was then converted to a slope analysis using ArcMap tools.

Figure 11: Hillshade

To determine Hillshade the staff utilized 1/9 Arc second DEM USGS (3 meter resolution) data clipped to the Tanyard Watershed Boundary. The DEM data was then converted to a hillshade analysis using ArcMap tools.

Figure 12: Residential Grass Evaluation

Using Talbot County parcels as a base all residential parcels were identified. Each parcel was visually examined and rated by comparing the brightness of the grass by using leaf-off aerial imagery and also by using WorldView II multispectral imagery. When the area was attributed it received a “Green Factor” score which was a number from 0-3 that categorized the brightness of the grass from dull (0) to very bright (3). The data was then clipped to the Tanyard Branch Watershed Boundary; and the coverage of the green grass was analyzed to determine acreage and percentage of watershed covered.

Figure 13: Wetlands

This data was received from the Maryland Department of Natural Resources and was clipped to the watershed boundary.

Figure 14: Soil Type

Using the boundary of the watershed as an Area of Interest (AOI), the staff clipped the NRCS soils data from the NRCS web soil survey site. The various types and acreages of various soils were then determined.

Figure 15: Hydric Soils

Using the boundary of the watershed as an Area of Interest (AOI), the staff clipped the NRCS soils data from the NRCS web soil survey site. This map shows whether the soils are hydric, partially hydric, or not hydric.

Figure 16: Soil Drainage

Using the boundary of the watershed as an Area of Interest (AOI), the staff clipped the NRCS soils data from the NRCS web soil survey site.

Figure 17: Ponding Frequency

Using the boundary of the watershed as an Area of Interest (AOI), the staff clipped the NRCS soils data from the NRCS web soil survey site. This map shows the ponding frequency.

Figure 18: Runoff Potential

Using the boundary of the watershed as an Area of Interest (AOI), the staff clipped the NRCS soils data from the NRCS web soil survey site. This map shows the soil runoff potential.

Figure 19: Curb Inlets

Using data collected from a related project with the Town of Easton, a map was generated to show all stormwater curb inlets within the watershed boundary.

In addition to the map products found in Appendix 10.1, additional GIS data layers and maps were made to show the overall distribution of retrofits. Figure 2 shows the distribution of proposed retrofits within the watershed.   Individual maps were produced for each retrofit location. These individual maps are found within this report for each retrofit. For each retrofit, the watershed drainage going into the retrofit was also calculated.

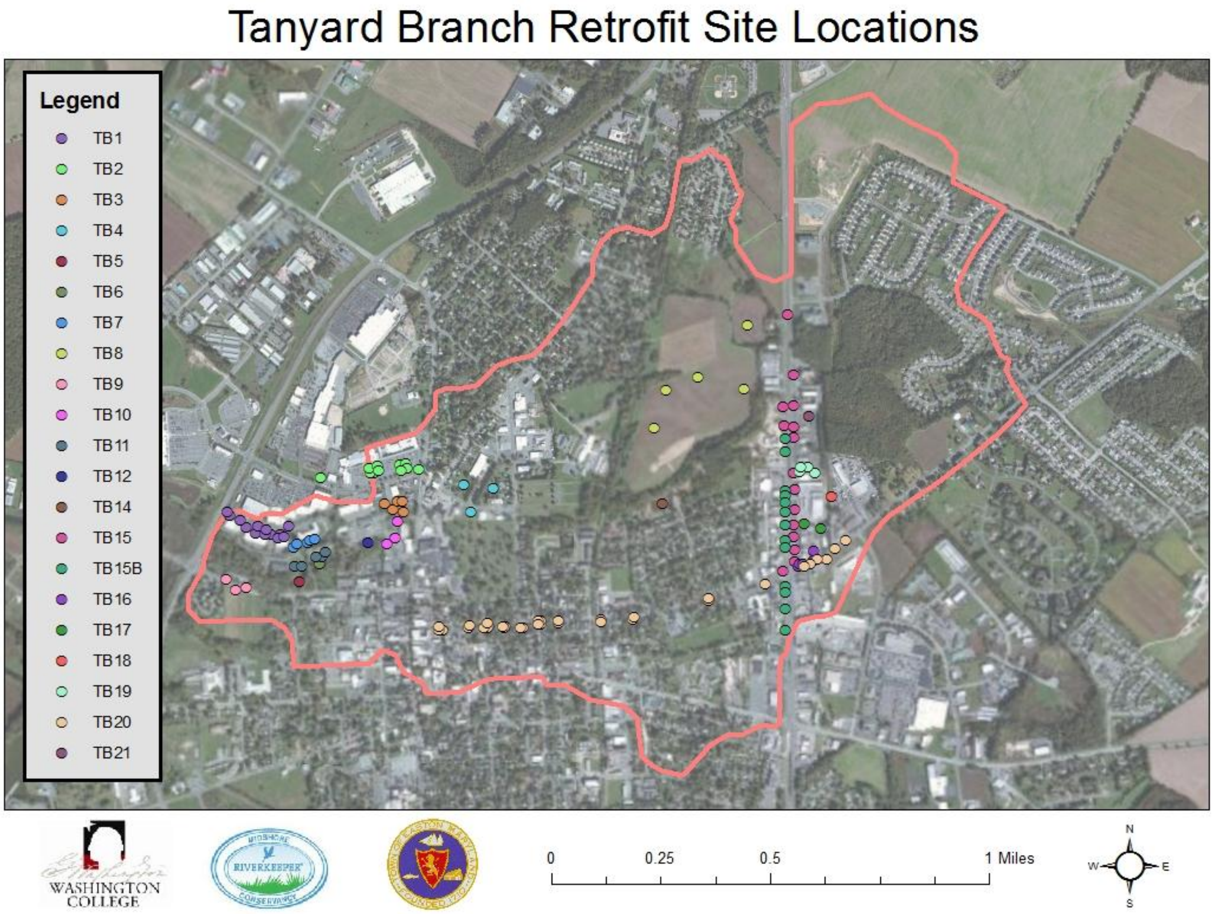


Figure 2. Retrofit Site Locations

ArcGIS Online was used to upload all GIS data into an easy to use web GIS interface hosted by ArcGIS Online with some of the data hosted on a Washington College GIS Server. Stakeholders in the watershed can access the data for the watershed via the Internet. The web site to access this data is as follows:

http://bit.ly/JA0Fgi

Aloft Aerial Photography attempted to capture pre and post storm events in the watershed. A pre-storm aerial video was captured and can be found on YouTube at;

https://www.youtube.com/watch?feature=player_embedded&v=JcspqnWVeDM

It was not possible during the grant period to capture post-storm events due to bad weather conditions that prohibited flying.

3.2 Field Surveys

MRC led watershed reconnaissance trips to assess stream conditions and upland areas for restoration and protection opportunities. During the field visits, the team assessed general stream health, selected potential monitoring stations and observed general conditions throughout the watershed.

MRC staff made use of the excellent data produced by the Washington College GIS Lab to assess watershed conditions. In addition, MRC conducted Neighborhood Source Assessments of each of the 5 neighborhoods. Typical neighborhoods were constructed between the 1880's and the early 2000's. One of the proposed management measures in this report is that the Town of Easton address the pollution contributed to the Tanyard Branch by these neighborhoods with a program to provide education on lawn care, demonstration rain gardens, rain barrels and turf reduction.

MRC staff investigated 75 candidate sites for retrofit potential. Through those visits we identified 67 retrofit projects at 22 locations that, if implemented, will slow and filter much of the stormwater in the watershed before it enters the storm drain network and Tanyard Branch. They would also significantly reduce the nitrogen and phosphorus loads to the tributary.

3.3 Water Testing

Project staff conducted water quality sampling to gain a better understanding of the location of pollution loads and to assess restoration potential.   Mr. Drew Koslow, Choptank Riverkeeper, and Dr. Christian Krafhorst, Washington College, Center for Environment & Society, were responsible for the field efforts. Our sampling sites are numbered beginning upstream to downstream as depicted in Figure 3 below with exact GPS locations listed in Table 1.

Figure 3. Sampling locations along Tanyard Branch.

Table 1. Exact locations of sampling sites.

MRC Sites			CES Sites		
Station	**Lat**	**Lon**	**Station**	**Lat**	**Lon**
	N	**W**		**N**	**W**
TB1	38.7832	76.0577	TB2	38.7836	76.0597
TB3	38.7813	76.0638	TB2b	38.7832	76.0604
TB4	38.7796	76.0677	TB4	38.7796	76.0681
TB5	38.7788	76.0770	TB5	38.7788	76.0770
TB6	38.7778	76.0802	TB8	38.7779	76.0850
TB7	38.7776	76.0807			

Water quality monitoring was conducted both during dry weather and storm events over the period May 2012 through October 2012 (Appendix Section 10.6). We collected data using a Yellow Springs Instruments (YSI) Professional Plus multi-parameter handheld water quality meter (MRC) and Sea Bird Electronics, Inc. CTD (CES). Dry weather water quality monitoring conducted by CES included water samples that were tested for nutrients (total nitrogen, ammonia, ortho-phosphate, silicate, and total organic N), total suspended solids (TSS), and chorophyll *a*. MRC collected data on temperature, dissolved oxygen, and pH during dry weather conditions and also made direct observations of stream conditions at the time of sampling. Both MRC and CES calibrated water quality instruments using certified standards prior use in the field.

During storm sampling, MRC staff measured stream flow using a Pasco Passport Flow Sensor and collected water samples during wet weather events that were processed at University of Maryland Center for Environmental Studies (UMCES) Horn Point Laboratory for total nitrogen and total phosphorus. Details on CES water quality monitoring and sample analysis are outlined in Appendix Section 10.5.

In addition, MRC staff ran models to estimate annual nitrogen and phosphorus loads to Tanyard Branch. These models are widely accepted in watershed management and provide a comprehensive view of trends in Tanyard Branch. Loading models were populated with data produced by the Washington College GIS Lab to maximize accuracy. Parameters that were input include land use, impervious coverage and population.

3.4 Results

Routine water quality monitoring revealed good to fair water quality conditions for dissolved oxygen (DO) and nitrogen (TN), but elevated phosphorus (TP) (Table 2). Throughout the year we noticed blooms of filamentous algae in stormwater ponds within the watershed and within Tanyard Branch from site TB3 downstream (Figure 4) and in the Bay Street Ponds. The presence of large mats of algae throughout the stream indicates an abundance of nutrients moving through the system and that the stream is over-enriched.

Table 2 Mean total nitrogen (TN) and total phosphorus (TP) concentrations for site TB5 (Tanyard Branch site 5), EPA standard, and a subwatershed in the Choptank River watershed. Total phosphorus for Tanyard Branch exceeds the EPA standard.

Parameter (mg/l)	TB5	EPA Standard*	Subwatershed of Choptank**
TN	1.00	1.35	5.80
TP	0.44	0.23	0.13
DO	8.64	5.00	7.20

*EPA standard for TN and TP are from Florida regulations
**From Nino de Guzman et al. 2012 for a subwatershed in Upper Choptank

Photo 1: Tanyard Branch just downstream from TB5, July, 2012. Large algal mats covered the whole reach between TB5 into the upper Bay Street Pond.

Photo 2: Tanyard Branch at TB3, October 2012. Heavy growth of algae covered much of the stream bottom.

Photo 3: Upper Bay Street Pond in July of 2012 with mats of algae.

Photo 4: A Green Frog in Tanyard Branch east of TB4. The frog is sitting in a thick mat of algae. July, 2012

Figure 4. Photos of algae growth within the Tanyard Branch.

Analysis of our nutrient data identifies that Tanyard Branch has elevated phosphorus levels (TP,Table 2, Table 3). At present there are no standards set for nutrient pollution in Maryland (in terms of concentration), but the Environmental Protection Agency (EPA) has produced phosphorus (TP) regulations for Florida that maintain 0.23 mg/l (mean for 5 Florida regions) for freshwater (EPA, 2010). Site TB5 phosphorus (TP)averaged 2X higher than the EPA standard, and approximately 4x higher than mean phosphorus concentration found at another subwatershed within the Choptank River watershed (Nino de Guzman et al., 2012) (Table 2). Generally, phosphorus concentrations over 0.03 mg/l will likely trigger algae blooms (EPA, 1986; Dunne and Leopold, 1978).

Table 3. Flow, temperature, dissolved oxygen (DO), total nitrogen (TN), total phosphorus (TP), ratio of TN to TP (N/P ratio), TN Load, and TP load for samples taken during low and high flow (highlighted rows).

Date	Flow (ft^3/s)	Temp (F°)	DO (mg/L)	TN (mg/L)	TP (mg/L)	N/P Ratio	N Load (lbs/day)	P Load (lbs/day)
5/16/2012	3.28	69.40	8.80	0.80	0.88	0.91	14.15	15.57
5/29/2012	1.16	74.80	9.80	1.20	0.58	2.07	7.51	3.63
7/16/2012	0.54	77.50	8.20	1.10	0.52	2.12	3.20	1.51
7/20/2012	0.63	79.50	7.90	0.80	0.41	1.95	2.72	1.39
8/10/2012	100	-	-	1.16	0.25	4.62	623.52	133.23
9/18/2012	30	-	-	0.83	0.21	3.97	134.79	34.14
10/25/2012	0.35	67.60	8.50	1.10	0.20	5.50	2.08	0.38
Average	-	73.76	8.64	1.00	0.44	3.02	-	-

Mean nitrogen concentration (TN) was 1.0 mg/l. This is lower than the Florida EPA standard and also the mean concentration found by Nino de Guzman et al. (2012) within a subwatershed in the Choptank River watershed (Table 2). Due to the high phosphorus, Tanyard Branch is nitrogen limited, which means that there is excess loading of phosphorus relative to nitrogen, and as nitrogen enters the system it is quickly utilized by algae. This can be determined by the ratio of TN/TP. Any ratio below 20 is identified as nitrogen limited (Table 3) (Sakamoto, 1966; Turner et al., 2003; Zhang et al., 2008). A healthy freshwater stream is typically limited by phosphorous, thus Tanyard Branch is out of balance.

When looking at specific sites along the stream it is clear that along the whole Tanyard Branch there are TP levels that exceed the EPA standard (Appendix Section 10.6). There is one hotspot for TN near Route 50 at site TB2 (Appendix Section 10.6). This would indicate that there are diffuse sources of TP entering the stream, which is indicative of the large residential and commercial areas within the watershed. The TN hotspot near Route 50 could be a result of automobile pollution.

Tanyard Branch streamflow is very flashy. This is apparent when looking at the flow-duration curve (Figure 5). Streamflow was estimated using the Hydrological Simulation Model-Fortran (HSPF), developed by U.S. Environmental Protection Agency (EPA). The flow-duration curve is a cumulative frequency curve that shows the percentage of time that specified discharges were equaled or exceeded during a given period. The modeled period depicted in the graph is for 1300 days over the period 2006 to 2009. The graph displays that Tanyard Branch typically maintains relatively low streamflow, but increases dramatically during storm events. Storm events produce streamflows that are 40 to 80 times greater than low flow conditions.

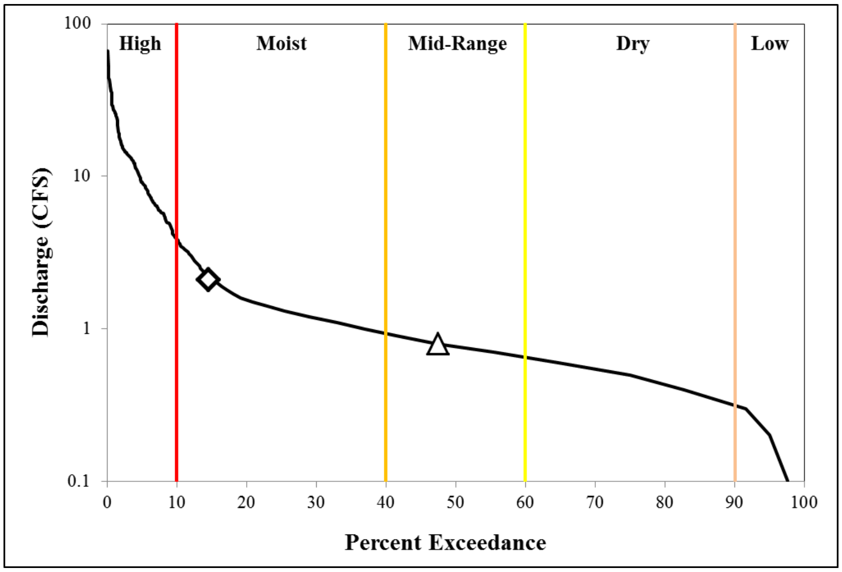


Figure 5. Flow-duration curve for modeled streamflow (discharge) in cubic feet per second (CFS) generated from HSPF model. High- storm events- streamflow at this volume occur <10% of the time, Moist- 10 to 40% exceedance- periods of excess rain (winter/spring). Mid-range- 40 to 60% transition to baseflow. Dry and Low- <60% exceedance Baseflow and drought condition, streamflow is usually greater than this except during droughts/late summer. Diamond identifies mean and triangle median.

Although high streamflow storm events are not common, this is the period when most of the streamflow and loading occurs and would need to be managed. This can be seen in Table 4, where average daily nutrient loads calculated from samples taken at station TB5 are projected to annual loads for both low flows (majority of the year) and storm events (in this case streamflows that are <5% on flow duration curve, or 18 events during the year). TN loading is 3x higher during storm events than during low to normal streamflow conditions.

It should be noted that bacteria sampling conducted by CES revealed elevated bacteria counts throughout Tanyard Branch. While these results are not unexpected in a heavily urbanized watershed, Easton may want to ask the local utility provider to test their sewage conveyance system for leakage.

Table 4. Measured daily nutrient loadings and projected annual loadings.

		N Load (lbs)	P Load (lbs)
Daily Loadings	Storm AVG	379.16	83.68
	Low Flow AVG	5.93	4.50
Projected Loadings	Storm Annual	6825	1506
	Low Flow Annual	2058	1560
	Total Annual Load	8883	3067

From the annual loadings, models were run in order to estimate what sectors produced the largest amount of nitrogen input into the system. Nitrogen loading was estimated by the methods of Costa et al. (1999). Phosphorus was modeled, but modeled results did not approximate measured loadings. The model used to generate table 5 (below) may underestimate loading from different areas because it is not calibrated directly for the TB watershed, but rather it uses generalizations from similar land uses to help best estimate where the largest nitrogen sources are within the watershed.

From this it is clear that the largest sources of nitrogen to the Tanyard Branch are commercial areas, roads, and parking lots (Table 5). Based on this information retrofits were identified to provide treatment to the targeted areas. Retrofits that have been proposed in the next section would reduce both nitrogen and phosphorus loading, although nitrogen is discussed because it was effectively modeled and is the nutrient of greatest concern for the Chesapeake TMDL and consequently WIPs.

Table 5. Nitrogen loading by sector.

Source	N (lb/yr)	% N-load
Agriculture	319	4.3%
Forest	95	1.3%
Residential	872	11.7%
Commercial/Parking Lots	4297	57.8%
Roads	1794	24.1%
Animals	54	0.7%
Total	7431	100.0%

4.0 Draft Plan

4.1 Targeted Load Reduction Strategy

MRC has calculated load reductions based on the efficiencies of our recommended practices. We have calculated that if all practices are installed 1000 lbs of nitrogen per year could be captured by the floating wetlands, 951 pounds per year could be captured by bioretention projects and 888 lbs per year could be captured by the bioswales. This would result in an annual reduction of nitrogen loading by 2,839 pounds per year, capturing one-third of the annual load.

The majority of our retrofit projects are designed to capture unmanaged stormwater from parking lots and roads within the watershed. These impervious surfaces contribute a significant portion of the load and our recommended projects would capture approximately 60% of the nitrogen loading from these sources. Floating wetlands have been documented to be extremely efficient at nitrogen removal with an average cost for stormwater ponds of $48/lb of nitrogen. Bioretention costs are higher at $140/lb and, while there are fewer opportunities for bioswales, they would cost $48/lb.

4.2 Proposed Management Measures

MRC identified a suite of management measures that will reduce the pollution loading to Tanyard Branch to the point that water quality standards are met. This includes measures for county and state owned properties, for commercial properties, for residential properties, for businesses, and for agricultural sources of pollution to Tanyard Branch. These recommendations include a combination of stormwater retrofits, turf management strategies, agricultural practices, and management strategies for stormwater. The ranges of cost estimates in our report are based on actual contractor bids for sites of similar size and characteristics that were constructed Maryland within recent years.

Table 6 below enumerates the retrofit projects. They are identified by a geographic locator (e.g., TB1= Tanyard Branch site #1, which is the area around the Tred Avon Square Shopping Center where the Acme is located) and a modifier that identifies each recommended project by type (e.g., TB1-BF1 = Tanyard Branch, site 1, bio-filter #1.) The estimated size and cost of each individual project is listed with a low end and a high end cost estimate. We also total the cost of each geographic grouping of projects (Table 7).

Table 6. Retrofit Inventory with cost estimates by project

Site Name	Location	Practice	Size of practice	Cost (low)	Cost (high)
TB1-BF1	behind Acme	ultra-urban filters	3'x 3'	$800	$850
TB1-BF2	behind Acme	ultra-urban filters	3'x3'	$800	$850
TB1-BF3	Tred Avon Square	ultra-urban filters	3'x3'	$800	$850
TB1-BF4	behind Acme	ultra-urban filters	3'x3'	$800	$850
TB1-BR1	behind Acme	bioretention	900 sf	$4,000	$10,800
TB1-BR2	behind Acme	bioretention	450 sf	$2,250	$5,400
TB1-BS1	west of Acme	bioswale	1,500 sf	$3,000	$4,000
TB1-FD	Assorted French drains	French drains	650 lf	$1,300	$2,600
Cost for TB1				**$13,750**	**$26,200**
TB2-BS1	Easton Plaza	bioswale	930 sf	$1,860	$3,500
TB2-BS2	Easton Plaza	bioswales	520 sf	$1,040	$2,000
TB2-BR1	Easton Plaza	bioretention	2,000 sf	$10,000	$24,000
TB2-BR2	Easton Plaza	bioretention	1,100 sf	$5,500	$13,200
TB2-FD 1-8	Easton Plaza	French drains	700 lf	$1,400	$2,800
Cost for TB2				**$19,800**	**$45,500**
TB3-BR1	Marlboro Plaza	bioretention	6,700 sf	$33,500	$80,400
TB3-BS1	Marlboro Plaza	bioswale	270 sf	$540	$1,000
TB3-FD1	Marlboro Plaza	French drain	150 lf	$300	$900
Cost for TB3				**$34,340**	**$82,300**
TB4-BR1	Creamery Lane	bioretention	5,100 sf	$25,500	$61,200
TB4-BR2	Creamery Lane	bioretention	3,600 sf	$18,000	$43,200
TB4-BR3	Creamery Lane	bioretention	1,000 sf	$5,000	$12,000
Cost for TB4				**$48,500**	**$116,400**

TB5-FW1	Bay Street Pond 1	floating wetland	800 sf	$24,000	$30,000
TB6-FW-1	Bay Street Pond 2	floating wetland	800 sf	$24,000	$30,000
Cost for TB5 and TB6				**$48,000**	**$60,000**
TB7RG	County offices	rain gardens	700 sf	$1,900	$4,000
TB7-BS1	County offices	bioswale	760 sf	$1,620	$3,240
TB7-BS2	County offices	bioswale	600 sf	$1,320	$2,640
TB7-BS3	County offices	bioswale	600 sf	$1,320	$2,640
Cost for TB7		$12,000-15,00/ac		**$6,160**	**$12,520**
TB8-WRA-1	RTC Park Property	wetland restoration	23,323 sf	$1,500	$3,000
TB8-WRA-2	RTC Park Property	wetland restoration	287,260 sf	$20,000	$40,000
TB8-WRB	RTC Park Property	wetland restoration	60,256	$4,500	$9,000
TB8-WRC	RTC Park Property	wetland restoration	44,360 sf	$3,200	$6,400
TB8-WRD	RTC Park Property	wetland restoration	67,822 sf	$4,700	$9,400
TB8-TP	RTC Park Property	Tree Plantings	174,240 sf	12,500	$25,000
Cost for TB8			**483,021 sf (11.1 Ac)**	**$46,400**	**$92,800**
TB9BR1	Satellite property	bioretention	3,800 sf	$19,000	$45,600
TB9BS	Bay St.	bioswale	1,800 sf	$3,200	$6,400
Cost for TB9				**$22,200**	**$52,000**
TB10BRA	Easton Utilities	bioretention	3,180 sf	$15,900	$38,160
TB10BRB	Easton Utilities	bioretention	850 sf	$4,250	$10,200
TB10BRC	Easton Utilities	bioretention	800 sf	$4,000	$9,600
TB10BS	Easton Utilities	bioswale	570 sf	$1,140	$2,280
Cost for TB10				**$25,290**	**$60,240**
TB11-BR1	Bay St. Pond1	bioretention	800 sf	$4,000	$9,600
TB11-BR2	Bay St. Pond1	bioretention	800 sf	$4,000	$9,600
TB-11-BR3	Bay St. Pond2	bioretention	1800 sf	$9,000	$21,600
TB-11-FD1-2	Bay St. Pond 2	French drain	200 lf	$400	$800
TB11-BS1-2	Bay St. Pond 1	bioswale	430 sf	$860	$1720
Cost for TB11				**$18,260**	**$43,320**
TB12-BR1	Easton Utilities Yard	bioretention	1,400 sf	$7,000	$16,800
Cost for TB12				**$7,000**	**$16,800**
TB-13-RB	residential property	rain barrels	200	50/barrel	$10,000
Cost for TB13					**$10,000**
TB14-FW	merrick lane sw pond	floating wetland	600	$18,000	$24,000
Cost for TB14				**$24,000**	**$24,000**
TB15-SHA-BR1	US 50- holliday inn	bioretention	3,000 sf	**$15,000**	**$36,000**
TB15-SHA-BR2	US 50 comfort inn	bioretention	3,750 sf	**$18,750**	**$45,000**
TB15-SHA-BR3	US 50 Denny's	bioretention	1,550 sf	**$7,750**	**$18,600**

TB15-SHA-BR4	US 50 Sonic	bioretention	650 sf	**$3,250**	**$7,800**
TB15-SHA-BR5	US 50- Easton Diner	bioretention	1,000 sf	**$5,000**	**$12,000**
TB15-SHA-BR6	US 50- Pro build (N)	bioretention	1,500 sf	**$7,500**	**$18,000**
TB15-SHA-BR7	US 50- Pro build (S)	bioretention	1,700 sf	**$8,500**	**$20,400**
TB15-SHA-BR8	US 50- Sunoco-(N)	bioretention	200 sf	**$1,000**	**$2,400**
TB15-SHA-BR9	US 50- Sunoco	bioretention	1,600 sf	**$8,000**	**$19,200**
TB15-SHA-BR10	US 50- Sunoco (S)	bioretention	280 sf	**$1,400**	**$3,360**
TB15-SHA-BR11	US 50- Hardees	bioretention	1,600 sf	**$8,000**	**$19,200**
TB15-SHA-BR12	US 50- Goldsborough	bioretention	1,650 sf	**$8,250**	**$19,800**
TB15-SHA-BR13	US 50-NE Taylor	bioretention	1,600 sf	**$8,000**	**$19,800**
TB15-SHA-BR14	US 50-NE Taylor	bioretention/rehab	3,600 sf	**$18,000**	**$43,200**
TB15-SHA-BS1	US 50 median	bioswale	6,450 sf	**$12,900**	**$25,800**
TB15-SHA-BF	Curb inlets on US 50	ultra-urban filters	13	**$25,610**	**$25,610**
Cost for TB15				**$156,910**	**$336,170**
TB16-BR1	328 and Hardees	bioretention	1,200	**$6,000**	**$14,400**
TB16-FD1	Hardees parking lot	French drain	50 lf	**$100**	**$200**
TB16-FD2	Hardees parking lot	French drain	50 lf	**$100**	**$200**
TB16-BR2	Hardees	bioretention	600 sf	**$3,000**	**$36,000**
TB16-BR3	Hardees	bioretention	1,100 sf	**$5,500**	**$13,200**
Cost for TB16				**$14,700**	**$64,000**
TB17-BR/WR	Sunoco	bioretention/wetlands	4,300 sf	**$21,500**	**$51,600**
TB17-BR2	Sunoco	bioretention	1200 sf	**$6,000**	**$14,400**
Cost for TB17				**$27,500**	**$67,000**
TB18-BR1	LKQ Trucks/Transaxle	bioretention	9,000 sf	**$45,000**	**$108,000**
Cost for TB18				**$45,000**	**$108,000**
TB19-BR1	South of Easton Diner	bioretention	1,600 sf	**$8,000**	**$19,200**
TB19-BR2	South of Easton Diner	bioretention	3,800 sf	**$19,000**	**$45,600**
TB19-FD	Easton Diner lot	French drain	200 lf	**$400**	**$600**
Cost for TB19				**$27,400**	**$65,400**
TB20-BF	Goldsborough St curb inlets	ultra-urban filters	32	**$50,000**	**$59,400**
Cost for TB20				**$50,000**	**$59,400**
TB21-BS1	south Comfort Inn	bioswale	600 sf	**$1,200**	**$2,400**
Cost for TB21				**$1,200**	**$2,400**

Table 7. Cost Estimate and Priority Ranking for Retrofit Projects by location.

Location	Low Cost	High Cost	Priority
TB1	$13,750	$26,200	2
TB2	$19,800	$45,500	2
TB3	$34,340	$82,300	2
TB4	$48,500	$116,400	2
TB5	$24,000	$30,000	1
TB6	$24,000	$30,000	1
TB7	$6,160	$12,520	3
TB8	$46,400	$92,800	2
TB9	$22,200	$52,000	2
TB10	$25,290	$60,240	2
TB11	$18,260	$43,320	2
TB12	$7,000	$16,800	2
TB13	$10,000	$10,000	2
TB14	$18,000	$24,000	2
TB15-SHA	$156,910	$336,170	1
TB16	$14,700	$64,000	2
TB17	$27,500	$67,000	2
TB18	$45,000	$108,000	2
TB19	$27,400	$65,400	2
TB20	$50,000	$59,400	2
TB21	$1,200	$2,400	2
Total Cost Estimate	$640,410	$1,341,450	

The Cost estimate table above shows both low-end and high-end costs since contractor prices and work quality can vary greatly. Estimates are derived from actual contractor bids on similar projects in Maryland.

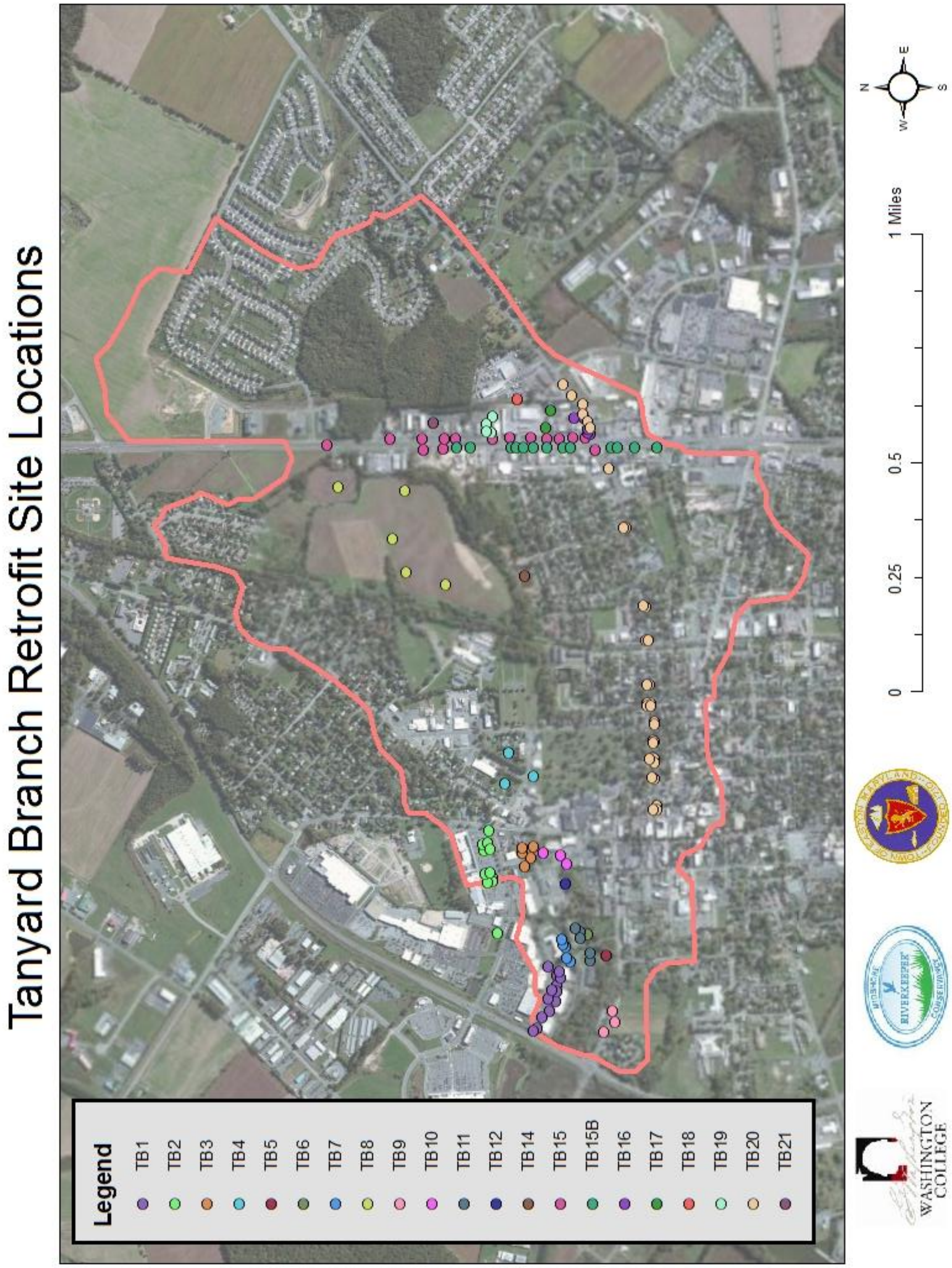
<u>Maintenance Costs for Retrofits</u>

Floating Wetlands- Maintenance costs for five years are included in the $30,000 high cost estimate provided in Table 6. The low cost estimate of $24,000 does not include maintenance. Both companies providing estimates for this report indicated that installation and maintenance for the Bay Street floating wetlands are fairly predictable and five years of maintenance should cost approximately $6,000.

Rain-Gardens/Bioswales/Bioretentions- The cost for maintaining one of these practices will be somewhat dependent upon the amount of sediment accumulating in the practice and in the curb cuts that allow water to flow into the practice. Generally speaking, approximately $200 per year should cover the cost of sediment removal, plant replacement, replacing drain stone/ cobble, replacing wood chips or mulch, and for trash bags for sediment and other debris. Plant material in these practices will need to be weeded periodically. Until plants become established they will also need to be watered. Volunteer labor could reduce maintenance costs.

Ultra Urban Filters- The ultra-urban filters are supplied with mounting brackets, and hardware to install the filters. The filters themselves are 13”x 13” x 21” and stay in place by gravity so replacement is very simple. A 5’ curb inlet requires 4 filters and a flow diverter to divert flow from the gap into the end filter. The filters themselves have a two-year lifespan and replacement cost as of 11/15/2012 is $280 per filter ($1,120 for four) plus shipping and handling. There would also be some labor costs involved in pulling and disposing of the old filters.

Retrofit Maps



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TB1 Tred Avon Square

Retrofits: **7**

Watershed Size: **7.43 acres**

Cost per lb: **$104**-**$199** (w/o ultra-urban filters)

Cost estimate: **$13,750-$26,200**

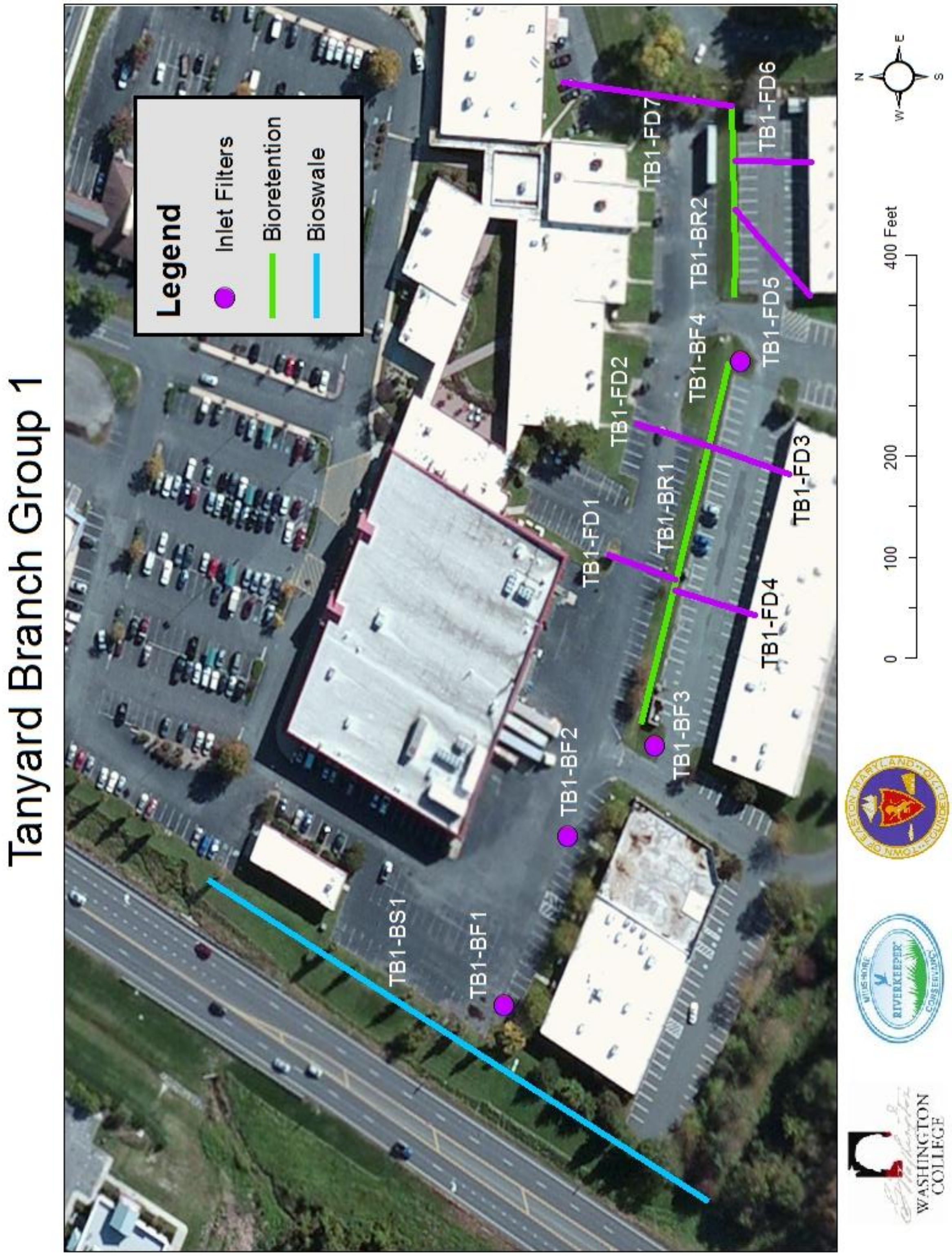
Priority level: **2**

Retrofit Code	Owner Name		Acct #
TB1-BF1	Tred Avon LLC	C/O Greenberg Commercial	2101009524
TB1-BF2	Tred Avon LLC	C/O Greenberg Commercial	2101009524
TB1-BF3	Mears Properties LLC		2101083872
TB1-BF4	Mears Properties LLC		2101083872
TB1-BR1	Eastern Shore Retirement	Associates Limited Partnership	2101085255
TB1-BR2	Eastern Shore Retirement	Associates Limited Partnership	2101085212

Site Name	Location	Practice	Size of practice	Cost (low)	Cost (high)	N Reduction (lbs)
TB1-BF1	**behind Acme**	**ultra-urban filters**	**3'x3'**	**$800**	**$850**	**132**
TB1-BF2	**behind Acme**	**ultra-urban filters**	**3'x3'**	**$800**	**$850**	
TB1-BF3	**behind Acme**	**ultra-urban filters**	**3'x3'**	**$800**	**$850**	
TB1-BF4	**behind Acme**	**ultra-urban filters**	**3'x3'**	**$800**	**$850**	
TB1-BR1	**behind Acme**	**bioretention**	**900 sf**	**$4,000**	**$10,800**	
TB1-BR2	**behind Acme**	**bioretention**	**450 sf**	**$2,250**	**$5,400**	
TB1-BS1	**west of Acme**	**bioswale**	**1,500 sf**	**$3,000**	**$4,000**	
TB1-FD1-8	**Directs drainage to BS1 &2**	**French drain**	**645 lf**	**$1,290**	**$2,580**	

TB1- Tred Avon Square is a large shopping center constructed with minimal stormwater management. There are approximately 7.5 acres of impervious surfaces between parking lots and rooftops that drain to Tanyard Branch. We recommend constructing two linear bioretention cells in grass swales located behind the Acme (TB1-BR1 and TB1-BR2) with 8 French drains that direct water away from storm drain inlets and into bioretention facilities. In addition, we recommend installing ultra-urban filters with smart sponge to curb the flow of hydrocarbons and total suspended solids into receiving waters.

TB1 Tred Avon Square



TB2 Easton Plaza

Retrofits**: 4**

Watershed Size**: 5.85 Acres**

Cost per lb**: $231-$525**

Cost estimate: **$19,800- $45,500**

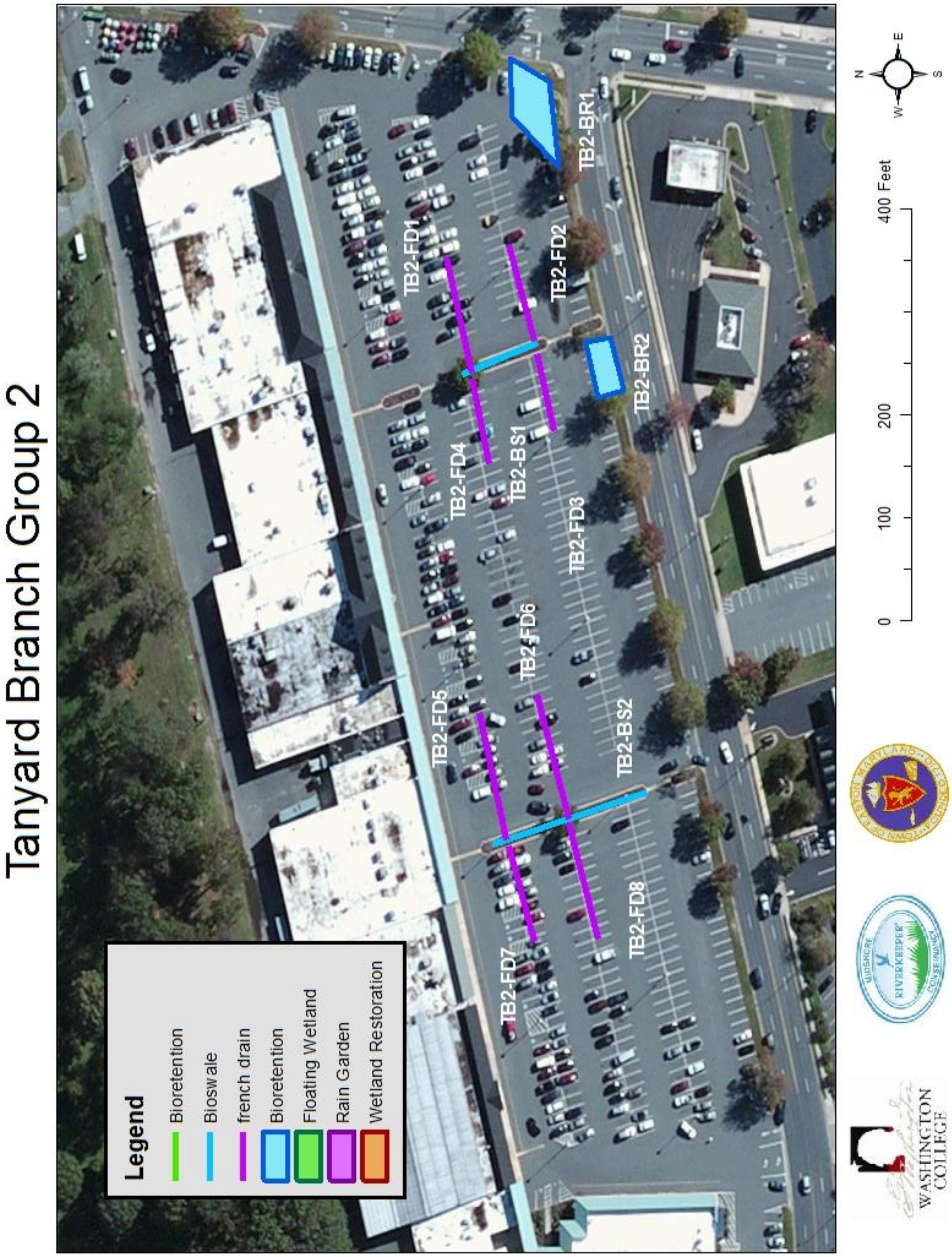
Priority level: **2**

Retrofit Code	Owner Name	Acct #
TB2-BR1	Easton Shopping Center LLC	2101063871
TB2-BS1	Easton Shopping Center LLC	2101063871
TB2-BS2	Easton Shopping Center LLC	2101063871

Site Name	Location	Practice	Size of practice	Cost (low)	Cost (high)	N Reduction (lbs)
TB2-BS1	Easton Plaza	bioswale	1,300 sf	$2,600	$3,500	86
TB2-BS2	Easton Plaza	bioswale	1,300 sf	$2,600	$3,500	
TB2-BR1	Easton Plaza	bioretention	2,000 sf	$10,000	$24,000	
TB2-BR2	Easton Plaza	bioretention	1,100 sf	$5,500	$13,200	
TB2-FD1-8	Easton Plaza	French drains	3,800 sf	$7,600	$11,400	

TB2- Easton Plaza is another urban shopping center in Easton with no existing stormwater management. There are about 6 acres of impervious surfaces on this site including rooftops and parking lots. We recommend converting a minimal number of parking spaces in two key locations to construct bioretention facilities. In addition, we recommend converting the grassy medians into linear bioswales that run down each pavement edge (two in each green area), and to enhance drainage to the bioswales by constructing grated French drains perpendicular to the swales.

TB2 Easton Plaza



TB3 Marlboro Plaza

Retrofits: **3**

Watershed size: **2.67 acres**

Cost per l b.: **$1098**-**$2633**

Cost estimate**: $34,340-$82,300**

Priority: **2**

Retrofit Code	Owner Name		Acct #
TB3-BR1	Marlboro Plaza Business Trust		2101064193
TB3-BS1	Mears Properties LLC	C/O Walter R. Stone	2101064166

Site Name	Location	Practice	Size of practice	Cost (low)	Cost (high)	N Reduction (lbs)
TB3-BR1	**Marlboro Plaza**	**bioretention**	**6,700 sf**	**$33,500**	**$80,400**	**31**
TB3-BS1	**Marlboro Plaza**	**bioswale**	**270 sf**	**$540**	**$1,000**	
TB3-FD1	**Marlboro Plaza**	**French drain**	**150 lf**	**$300**	**$900**	

TB3- Marlboro Plaza is located across Marlboro Road from Easton Plaza. Again there is a relatively large amount of impervious coverage, and this site receives runoff from adjacent parcels. There is an excellent opportunity for a 6,700 square foot regional bioretention facility that receives 2.67 acres of runoff. It is located on the undeveloped property behind the Plaza. Permission of the owner of the property would be required. It is recommended to bypass the existing stormwater inlet by constructing French drain 1 in front of the storm drain to direct additional water to the bioretention cell.

TB3 Marlboro Plaza

TB4 Creamery Lane

Retrofits: **3**

Watershed Size: **4.36 acres**

Cost per lb: **$257-$616**

Cost: **$48,500-$116,400**

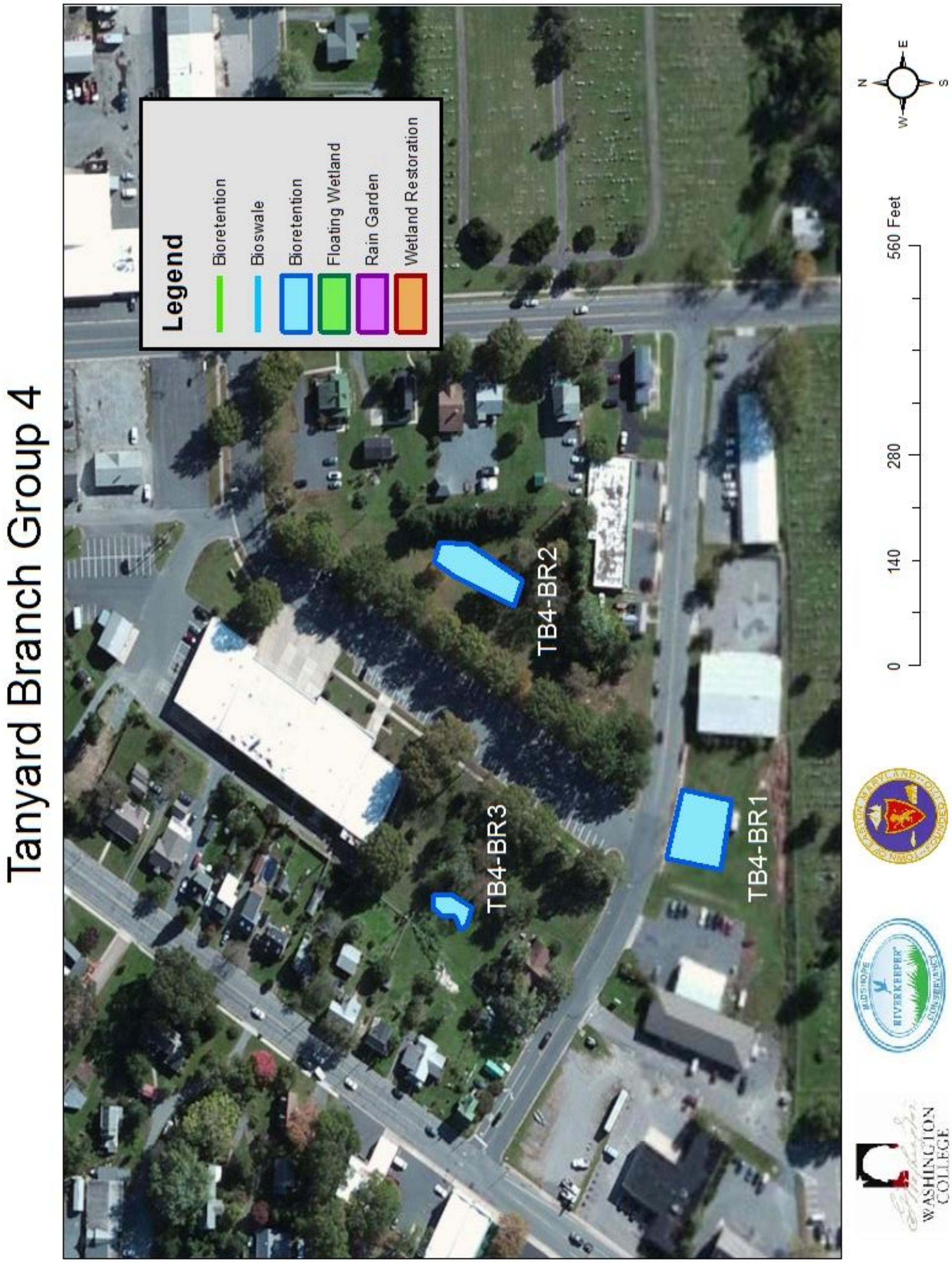
Priority level: **2**

Retrofit Code	Owner Name	Acct #
TB4-BR1	C.S. Tarbutton, Inc.	2101005820
TB4-BR2	Town of Easton	2101027220
TB4-BR3	Town of Easton	2101027220

Site Name	Location	Practice	Size of practice	Cost (low)	Cost (high)	N reduction (lbs)
TB4-BR1	**Creamery Lane**	**bioretention**	**5,100 sf**	**$25,500**	**$61,200**	**189**
TB4-BR2	**Creamery Lane**	**bioretention**	**3,600 sf**	**$18,000**	**$43,200**	
TB4-BR3	**Creamery Lane**	**bioretention**	**1,000 sf**	**$5,000**	**$12,000**	

TB4: This area is a mixed use commercial and residential neighborhood most of which was constructed without any stormwater management. There is a very high amount of impervious coverage in this area as well. We recommend a 5,100 sf regional bioretention cell in a vacant lot. In addition, we recommend a 3,600 sf bioretention facility on the open space across from the Easton Volunteer Fire Department (VFD) and a small facility just south of the Easton VFD.

TB4 Creamery Lane



TB5 Bay Street Pond 1

Retrofits: **1**

Watershed Size: **846.9 acres**

Cost per lb: **$48-$60**

Cost: **$24,000- $30,000**

Priority Level**: 1**

Site Name	Location	Practice	Size of practice	Cost (low)	Cost (high)	N Reduction (lbs)
TB5-FW1	**Bay Street Pond 1**	**floating wetland**	**800 sf**	**$24,000**	**$30,000**	**500**

TB5: Floating wetlands Bay Street Pond. This property is owned by The Waterfowl Festival. Ron Flohr, the president of the Waterfowl Festival, is receptive to the floating wetland concept and even the possibility that the Waterfowl Festival might be a financial supporter of such a project. Floating wetlands are the only practice recommended to be in-stream. They provide a cost-effective opportunity to reduce nutrient loads in Tanyard Branch and receiving waters. The high-end cost estimate includes three years of maintenance to the floating wetland. A source of electricity for the compressor will need to be obtained.

TB5 Bay Street Pond 1

TB6 Bay Street Pond 2

Retrofits: **1**

Watershed Size: **842.0 Acres**

Cost per lb: **$48-$60**

Cost: **$24,000- $30,000**

Priority: **1**

Site Name	Location	Practice	Size of practice	Cost (low)	Cost (high)	N Reduction (lbs)
TB6-FW-1	**Bay Street Pond 2**	**floating wetland**	**800 sf**	**$24,000**	**$30,000**	**500**

TB5: Floating wetlands Bay Street Pond. This property is owned by The Waterfowl Festival. Ron Flohr, the president of the Waterfowl Festival, is receptive to the concept of floating wetlands and even the possibility that the Waterfowl Festival might be a financial supporter of such a project. Floating wetlands are the only practice recommended to be in-stream. They provide a cost-effective opportunity to reduce nutrient loads in Tanyard Branch and receiving waters. The high-end cost estimate includes three years of maintenance to the floating wetland. A source of electricity will need to be obtained for the compressor.

TB6 Bay Street Pond 2

TB7County Offices

Retrofits: **3**

Watershed Size: **2.2 acres**

Cost Per lb: **$264-$537**

Cost: **$6,160-$12,520**

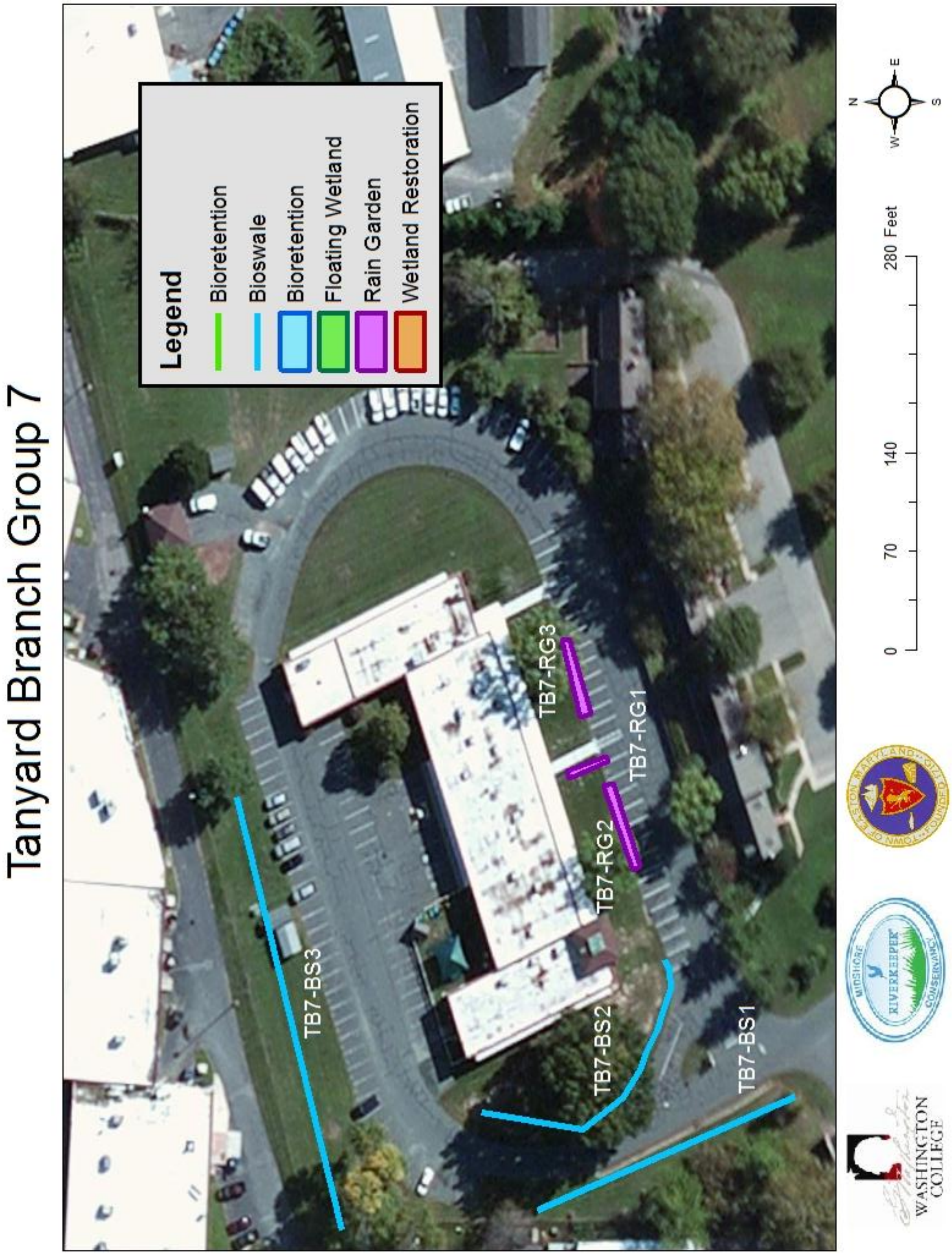
Priority: **2**

Retrofit Code	Owner Name	Acct #
TB7-BR	Talbot County, Maryland	2101014587
TB7-BS	Talbot County, Maryland	2101014587
TB7-RG	Talbot County, Maryland	210104587

Site Name	Location	Practice	Size of practice	Cost (low)	Cost (high)	N Reduction (lbs)
TB7-RG	County offices	rain gardens	700 sf	$1,900	$4,000	23
TB7-BS1	County offices	bioswale	760 sf	$1,620	$3,240	
TB7-BS2	County offices	bioswale	660 sf	$1,320	$2,640	
TB7-BS3	County offices	bioswale	660 sf	$1,320	$2,640	

TB7: County Offices. Again we have an area with significant impervious surfaces and relatively little existing stormwater management. This area offers an excellent opportunity for bioswales along the west end of the building that would capture runoff from the large driveway and some rooftop runoff. There is also an excellent opportunity for small demonstration rain gardens that would treat rooftop runoff and some of the southern parking lot. The bioretention facility above the upper Bay Street Pond is a low priority because no impervious drains to it.

TB7 County Offices



TB8 Easton's RTC Park Property

Retrofits: **6**

Watershed Size: **39.9 acres**

Cost: **$46,400-$92,800**

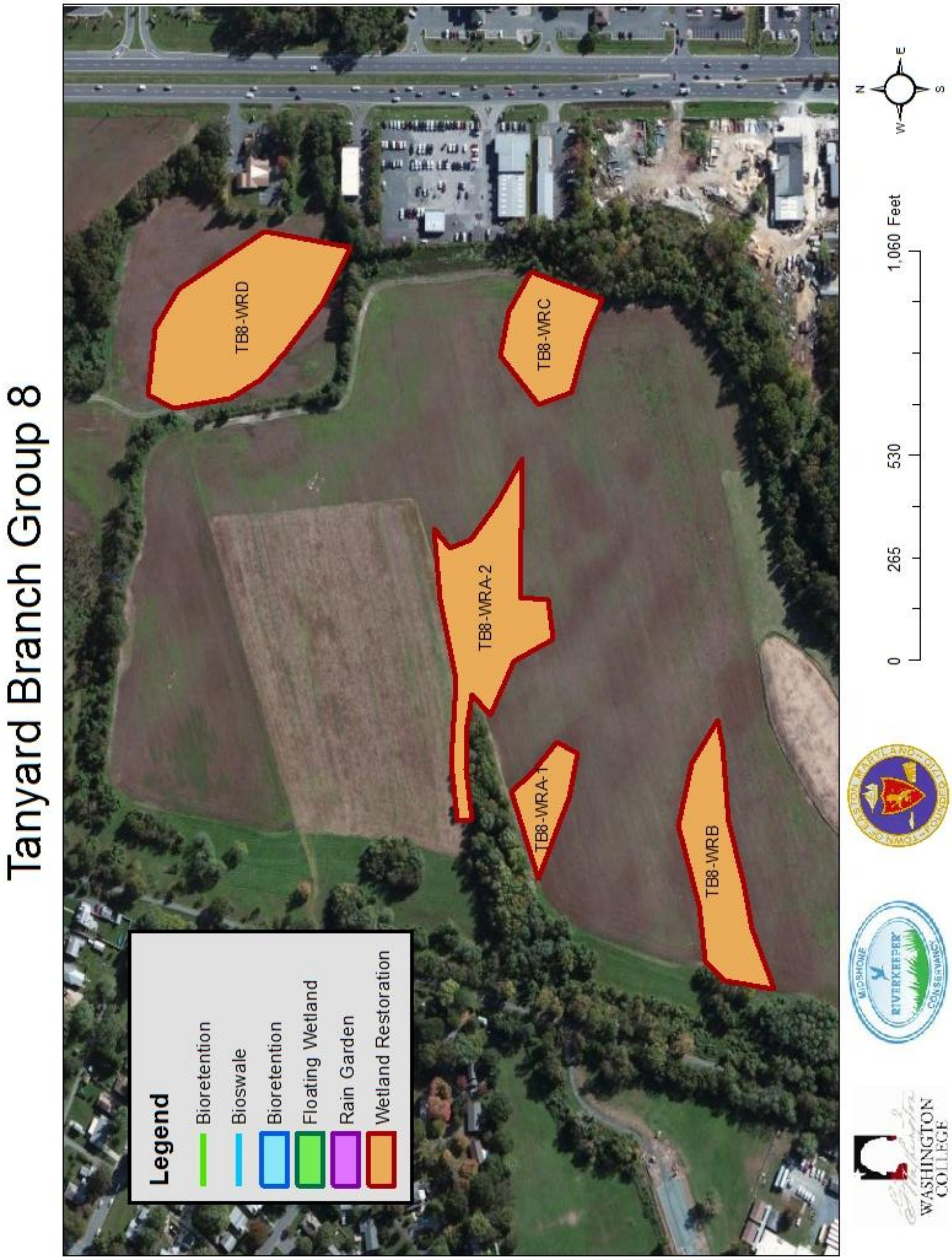
Priority level: **2**

etrofit Code	Owner Name		Acct #
TB8-WRA1	Town of Easton		2101064673
TB8-WRA2	Town of Easton		2101064673
TB8-WRB	Town of Easton		2101064673
TB8-WRC	Easton Commerce Center	Limited Partnership	2101063790
TB8-WRD	Easton Commerce Center	Limited Partnership	2101063790

Site Name	Location	Practice	Size of practice	Cost (low)	Cost (high)
TB8-WRA-1	**RTC Park**	**wetland restoration**	**23,323 sf**	**$1,500**	**$3,000**
TB8-WRA-2	**RTC Park**	**wetland restoration**	**287,260 sf**	**$20,000**	**$40,000**
TB8-WRB	**RTC Park**	**wetland restoration**	**60,256 sf**	**$4,500**	**$9,000**
TB8-WRC	**RTC Park**	**wetland restoration**	**44,360 sf**	**$3,200**	**$6,400**
TB8-WRD	**RTC Park**	**wetland restoration**	**67,822 sf**	**$4,700**	**$9,400**
TB8-TP	**RTC Park**	**Tree planting**	**174,240 sf**	**$12,500**	**$25,000**

TB8: The Town of Easton's RTC Park property has great potential to restore critical wetland habitat and also to plant trees to expand the buffer along Tanyard Branch. Forested wetlands provide ecological functions, process nutrients, store floodwaters and provide habitat for a variety of wildlife. There are approximately 11 acres of area mapped in hydric soils, with a wet signature that could be restored to forested wetlands for a very low relative cost. In 2002, the Baltimore District of the U.S. Army Corps of Engineers proposed to restore 15 acres of forested wetlands and stream buffer. The project was not funded, but this could provide critical habitat within the town of Easton.

TB8 Easton's RTC Park Property



TB9 Satellite Site/Pump Station

Retrofits: **3**

Watershed Size: **42.8 acres**

Cost per lb: **$34-$80**

Cost: **$22,200-$52,000**

Priority level: **2**

Retrofit Code	Owner Name	Acct #
TB9-BR1	Town of Easton	2101027077
TB9-BS1	Town of Easton	2101026887
TB9-BS2	Town of Easton	2101027077

Site Name	Location	Practice	Size of practice	Cost (low)	Cost (high)	N Reduction (lbs)
TB9BR1	**Satellite property**	**bioretention**	**3,800 sf**	**$19,000**	**$45,600**	**653**
TB9BS	**Bay St.**	**bioswales**	**1,800 sf**	**$3,200**	**$6,400**	

TB9: Satellite Property, Bay Street. Again we have an area with almost no existing stormwater management and significant drainage from Bay Street. We identified an area for a regional bioretention facility (south of the underground cables). In addition bioswales could be installed on both sides of Bay Street in the vicinity to provide further opportunity for nutrient processing.

TB9 Satellite Site/Pump Station

TB10 Easton Utilities

Retrofits: **4**

Watershed Size: **3.1 acres**

Cost per lb: **$1000-$2384**

Cost: **$25,290-$60,240**

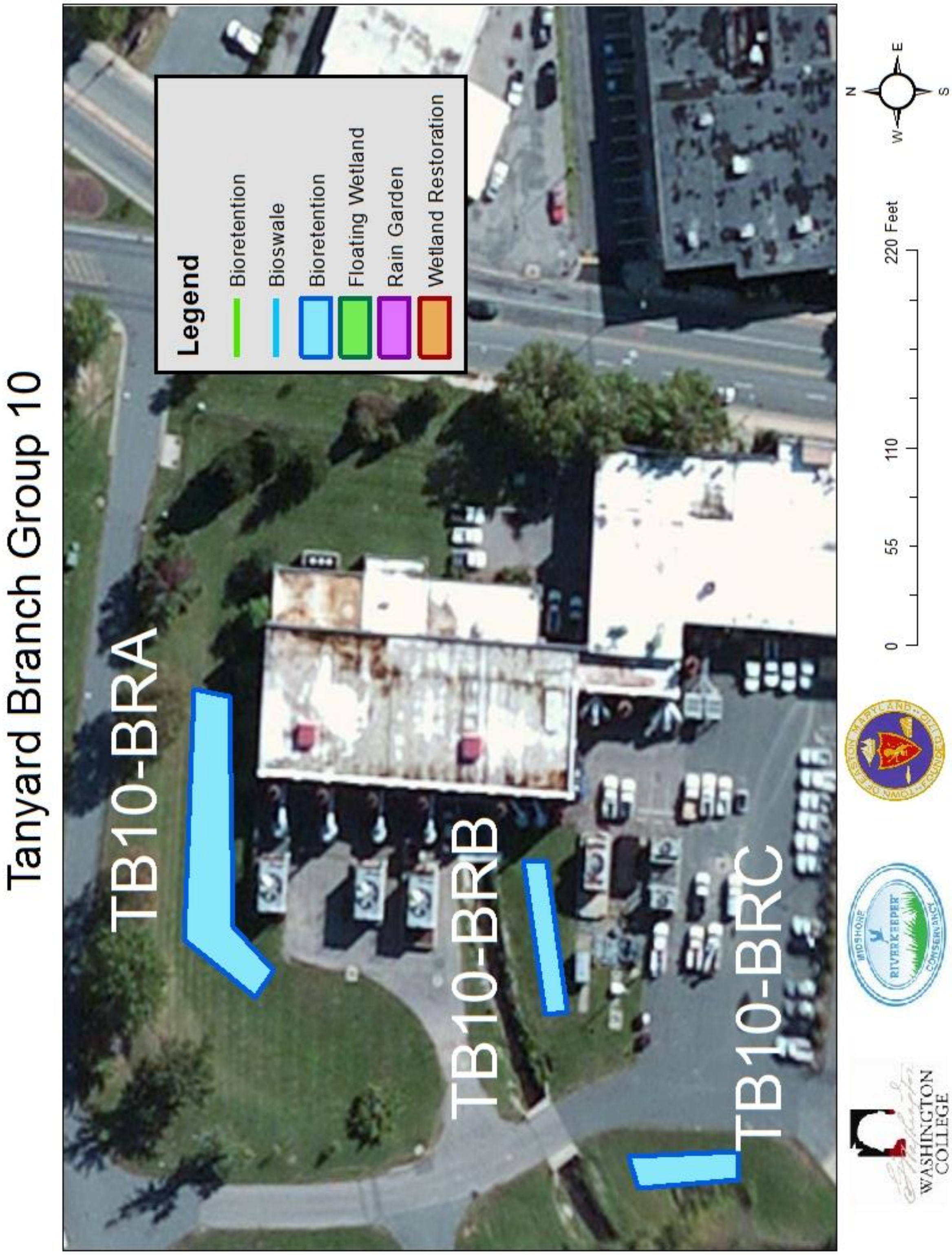
Priority: **2**

Retrofit Code	Owner Name	Acct #
TB10-BRA	Town of Easton	2101027093
TB10-BRB	Town of Easton	2101027093
TB10-BRC	Town of Easton	2101027123

Site Name	Location	Practice	Size of practice	Cost (low)	Cost (high)	N Reduction (lbs)
TB10BR1	**Easton Utilities**	**bioretention**	**3,180 sf**	**$15,900**	**$38,160**	**25**
TB10BR2	**Easton Utilities**	**bioretention**	**850 sf**	**$4,250**	**$10,200**	
TB10BR3	**Easton Utilities**	**bioretention**	**800 sf**	**$4,000**	**$9,600**	
TB10BS	**Easton Utilities**	**bioswale**	**570 sf**	**$1,140**	**$2,280**	

TB10: Easton Utilities. This property has very little existing stormwater management. There are a number of at-grade stormwater inlets that should be considered prime sites for ultra-urban filters. In addition there are three areas that would provide excellent sites for bioretention cells: on the south side of Tanyard Branch where it resurfaces from underground, on the north side of the generation building, and at an existing stormwater wetland facility where this enhancement would add significant benefit to the watershed.

TB10 Easton Utilities



TB11 Bay Street Ponds

Retrofits: **3**

Watershed Size: **5.5 acres**

Cost per lb: **$407-$966**

Cost: **$18,260-$43,320**

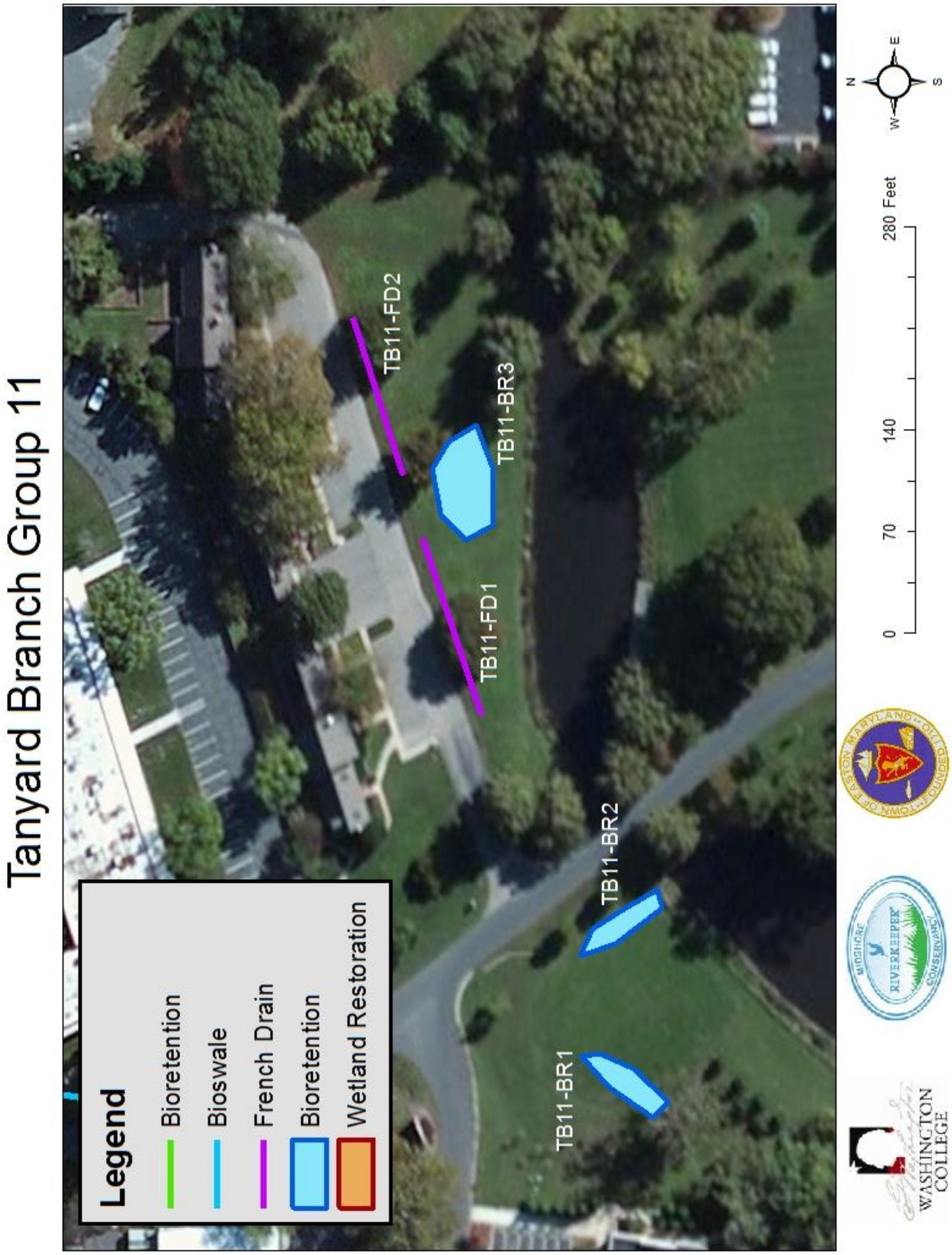
Priority: **3**.

Retrofit Code	Owner Name		Acct #
TB11-BR1	Bay Street Ponds, LLC	C/O Grayce B. Kerr Fund, Inc.	2101025775
TB11-BR2	Talbot County, Maryland		2101063189
TB11-BR3	Talbot County, Maryland		2101063189

Site Name	Location	Practice	Size of practice	Cost (low)	Cost (high)	N Reduction (lbs)
TB11-BR1	**Bay St. Pond1**	**bioretention**	**800 sf**	**$4,000**	**$9,600**	**45**
TB11-BR2	**Bay St. Pond1**	**bioretention**	**800 sf**	**$4,000**	**$9,600**	
TB-11-BR3	**Bay St. Pond2**	**bioretention**	**1800 sf**	**$9,000**	**$21,600**	
TB-11-FD1-2	**Bay St. Pond 2**	**bioswale**	**430 sf**	**$860**	**$1,720**	

TB11: Bay Street Ponds. The land surrounding the Bay Street Ponds offers opportunities to filter stormwater before it enters the Tanyard Branch. There are two ideal locations for small bioretention facilities north of the lower Bay Street Pond. We recommend creating small sections of bioswale to trap and funnel stormwater to the facilities. On the north side of the upper Bay Street pond we recommend a large bioretention facility with French drains bringing water to it. A large regional facility will significantly reduce pollutant loads to Tanyard Branch.

TB11 Bay Street Ponds



TB12 Easton Utilities Yard

Retrofits: **1**

Watershed Size: **5.6 acres**

Cost per lb: **$153-$369**

Cost: **$7,000-$16,800**

Priority: **2**

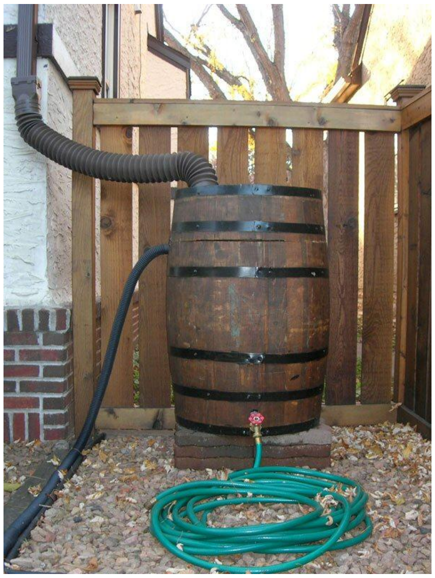
Retrofit Code	Owner Name	Acct #
TB12-BR1	Town of Easton	2101027050

Site Name	Location	Practice	Size of practice	Cost (low)	Cost (high)	N Reduction (lbs)
TB12-BR1	**Easton Utilities Yard**	**bioretention**	**1,400 sf**	**$7,000**	**$16,800**	**46**

TB12: Easton Utilities Yard. This site is typical with high impervious coverage and no existing stormwater management. We recommend a linear bioretention facility with sand berm filters. This will reduce nutrients and the sand filters will capture oil and grease leaving this heavy use area.

TB12 Easton Utilities Yard

TB13 Residential Rain Barrels



Cost: **$10,000 for 200 rain barrels**. **Rain gardens** can be built for **$2-4/square foot**.

Priority: **3**

This project is aimed to create awareness within the community about the importance of stormwater management and help better educate the citizens about environmental problems in the community

Site Name	Location	Practice	Size of practice	Cost (low)	Cost (high)	N reduction (lbs)
TB-13-RB	residential property	rain barrels	200 sf	50/barrel	$10,000	N/A

TB13: The 1200 residences in the Tanyard watershed. An important component to improving water quality in the Tanyard Branch watershed is the cumulative effect of small residential projects that collectively shave the peak off of rain events. To that end, we recommend a watershed rain barrel and rain garden program. These projects serve to educate homeowners and collectively can reduce the volume entering storm drains in a heavy rainstorm. Funders are often eager to support this type of community outreach/restoration effort.

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TB14 Merrick Lane Stormwater Pond

Retrofits: **1**

Watershed Size: **35.2 acres**

Cost per lb: **$48-$60**

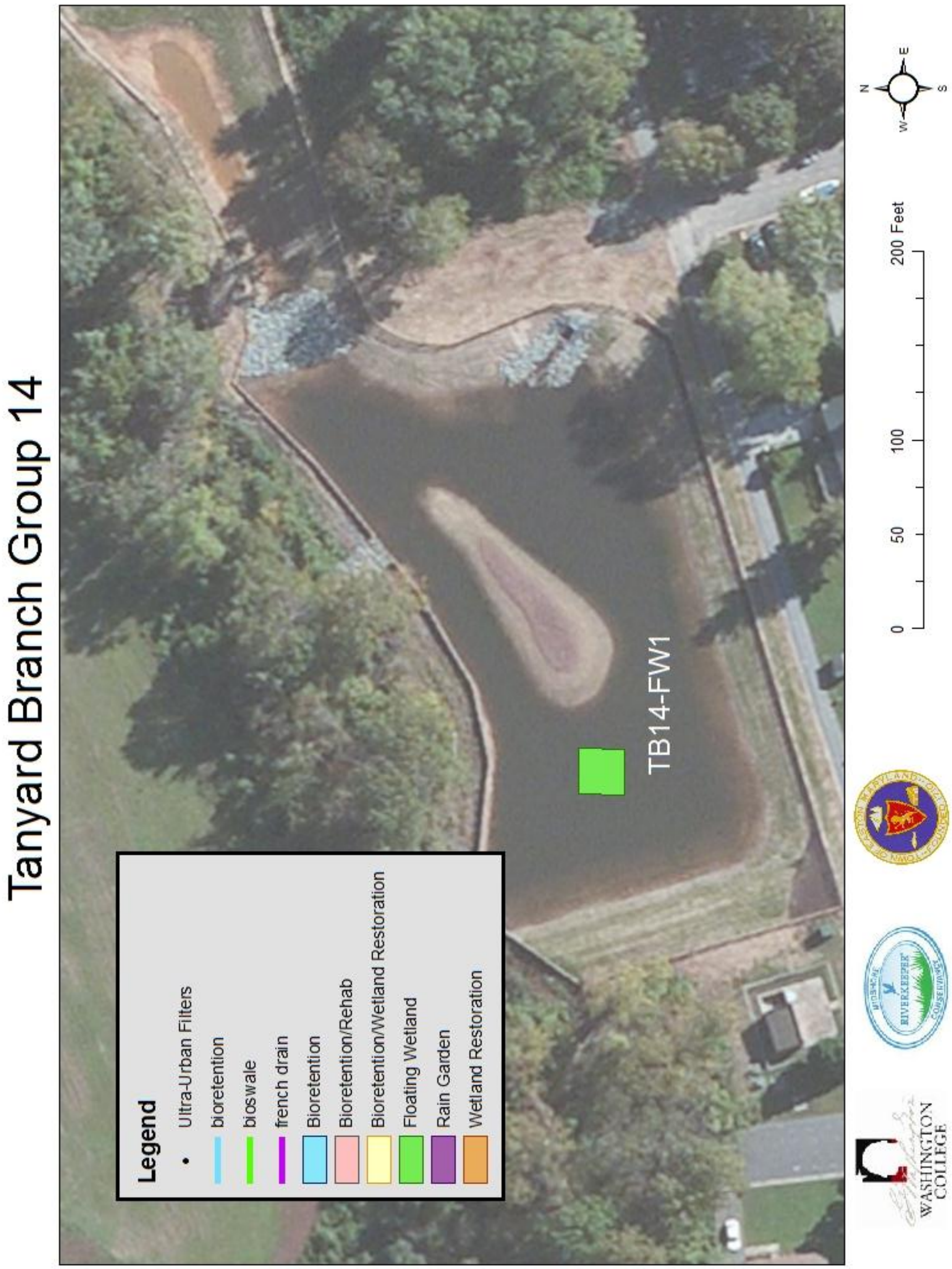
Cost: **$18,000-$24,000**

Priority: **2**

Site Name	Location	Practice	Size of practice	Cost (low)	Cost (high)	N Reduction (lbs)
TB14-FW	merrick lane sw pond	floating wetland	600 sf	$18,000	$24,000	500

TB14: Merrick Lane Stormwater Pond. This location offers an opportunity to remove significant amounts of nutrients from the system and to enhance the beauty and biological integrity of this stormwater feature. Ideally, providing a source of electricity for a compressor would enable this practice to function to its capacity.

TB14 Merrick Lane Stormwater Pond



TB15: State Highway Property along the U.S.50 corridor

Retrofits: **16**

Watershed Size: **39.3 acres**

Cost per lb: **$422-$904**

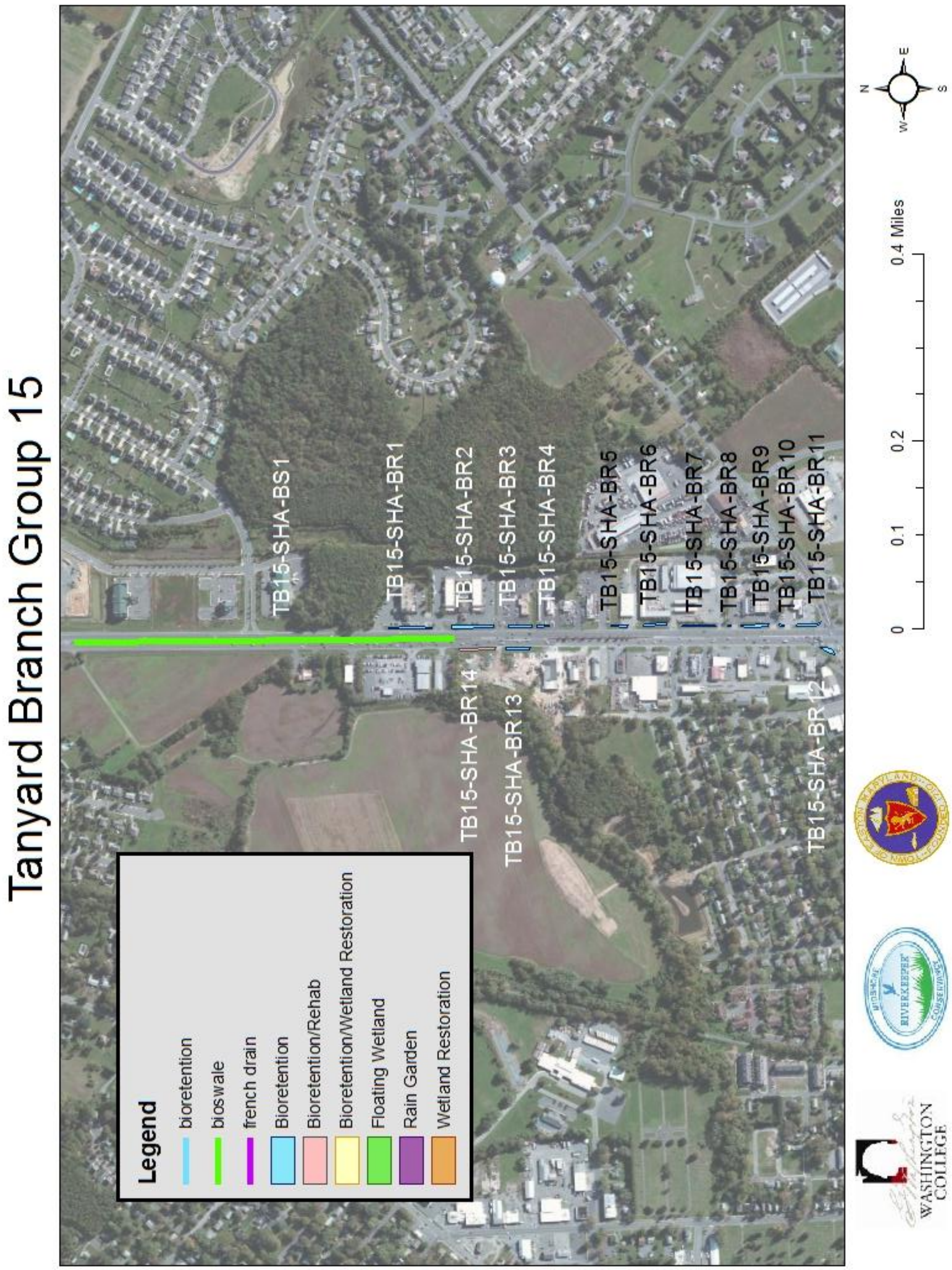
Cost: **$156,910-$336,170**

Priority: **1**

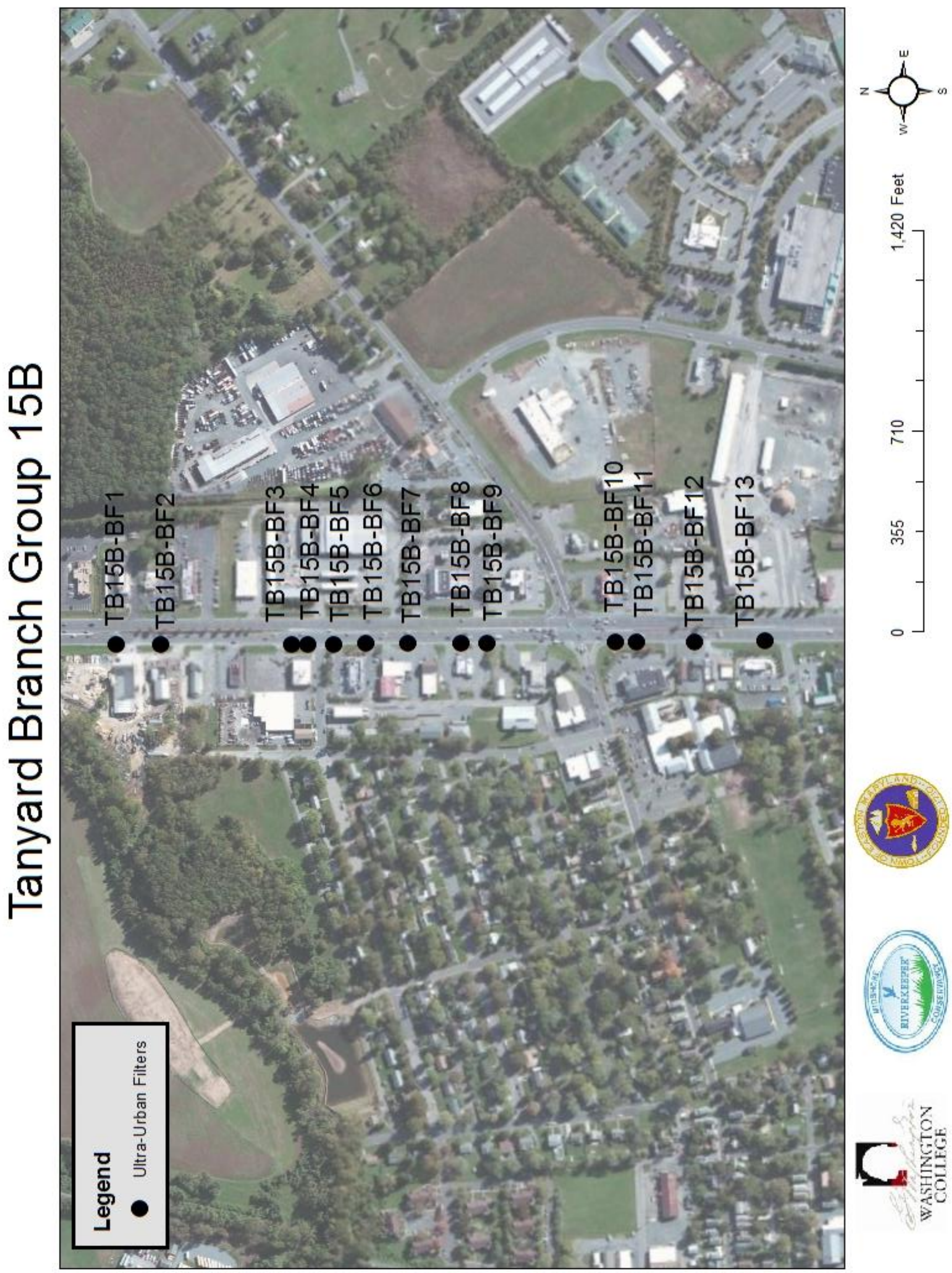
TB15: State Highway Property along the U.S.50 corridor. This location refers to 16 recommended bioretention projects, bioswales and ultra-urban filters within State Highway Administration's (SHA) right-of-way along route 50. BR1-BR11 are on the east side of US 50 and run from the Holiday Inn to the Hardee's at the intersection of MD 328. BR12-BR14 are located on the west side of US 50 and run from the Goldsborough Rd intersection to the swale in front of N.E. Taylor. Together, these projects offer an opportunity to remove significant amounts of nutrients from an identified hotspot.

Site Name	Location	Practice	Size of practice	Cost (low)	Cost (high)	N Reduction (lbs)
TB15-SHA-BR1	US 50- Holiday inn	bioretention	3,000 sf	$15,000	$36,000	2683
TB15-SHA-BR2	US 50 comfort inn	bioretention	3,750 sf	$18,750	$45,000	
TB15-SHA-BR3	US 50 Denny's	bioretention	1,550 sf	$7,750	$18,600	
TB15-SHA-BR4	US 50 Sonic	bioretention	650 sf	$3,250	$7,800	
TB15-SHA-BR5	US 50- Easton Diner	bioretention	1,000 sf	$5,000	$12,000	
TB15-SHA-BR6	US 50- Pro build (N)	bioretention	1,500 sf	$7,500	$18,000	
TB15-SHA-BR7	US 50- Pro build (S)	bioretention	1,700 sf	$8,500	$20,400	
TB15-SHA-BR8	US 50- Sunoco-(N)	bioretention	200 sf	$1,000	$2,400	
TB15-SHA-BR9	US 50- Sunoco	bioretention	1,600 sf	$8,000	$19,200	
TB15-SHA-BR10	US 50- Sunoco (S)	bioretention	280 sf	$1,400	$3,360	
TB15-SHA-BR11	US 50- Hardees	bioretention	1,600 sf	$8,000	$19,200	
TB15-SHA-BR12	US 50- Goldsborough	bioretention	1,650 sf	$8,250	$19,800	
TB15-SHA-BR13	US 50-NE Taylor	bioretention	1,600 sf	$8,000	$19,800	
TB15-SHA-BR14	US 50-NE Taylor	bioretention/rehab	3,600 sf	$18,000	$43,200	
TB15-SHA-BS1	US 50 median	bioswale	6,450 sf	$12,900	$25,800	
TB15-SHA-BF	Curb inlets on US 50	ultra-urban filters	13	$25,610	$25,610	

TB15: State Highway Property along the U.S.50 corridor



TB15: State Highway Property along the U.S.50 corridor



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TB16 Hardees Property

Retrofits: **5**

Watershed Size: **6.3 acres**

Cost per lb: **$288-$1254**

Cost: **$14,700-$64,000**

Priority: **2**

Retrofit Code	Owner Name Line 1	Owner Name Line 2	Account ID
TB16-BR1	Durham, Robert W., Trustee	C/O Tina Rogers, Controller	2101047639
TB16-FD1	Durham, Robert W., Trustee	C/O Tina Rogers, Controller	2101047639
TB16-FD2	Durham, Robert W., Trustee	C/O Tina Rogers, Controller	2101047639
TB16-BR2	Durham, Robert W., Trustee	C/O Tina Rogers, Controller	2101047639
TB16-BR3	Durham, Robert W., Trustee	C/O Tina Rogers, Controller	2101047639

Site Name	Location	Practice	Size of practice	Cost (low)	Cost (high)	N Reduction (lbs)
TB16-BR1	328 and Hardees	bioretention	1,200	$6,000	$14,400	51
TB16-FD1	Hardees parking lot	French drain	50 lf	$100	$200	
TB16-FD2	Hardees parking lot	French drain	50 lf	$100	$200	
TB16-BR2	Hardees	bioretention	600 sf	$3,000	$36,000	
TB16-BR3	Hardees	bioretention	1,100 sf	$5,500	$13,200	

TB16: Hardees property. This location is an opportunity to provide stormwater treatment to approximately 1 acre of impervious coverage with no existing facilities. We recommend a bioretention facility along Matthewstown Road within the county right-of-way, and two smaller bioretention cells within the Hardee's property. In addition, we recommend two French drains to direct stormwater from the building to the bioretention cell along Matthewstown Road.

TB16 Hardees Property

TB17 Sunoco Station

Retrofits: **2**

Watershed Size: **3.0 acres**

Cost per lb: **$1125-$2740**

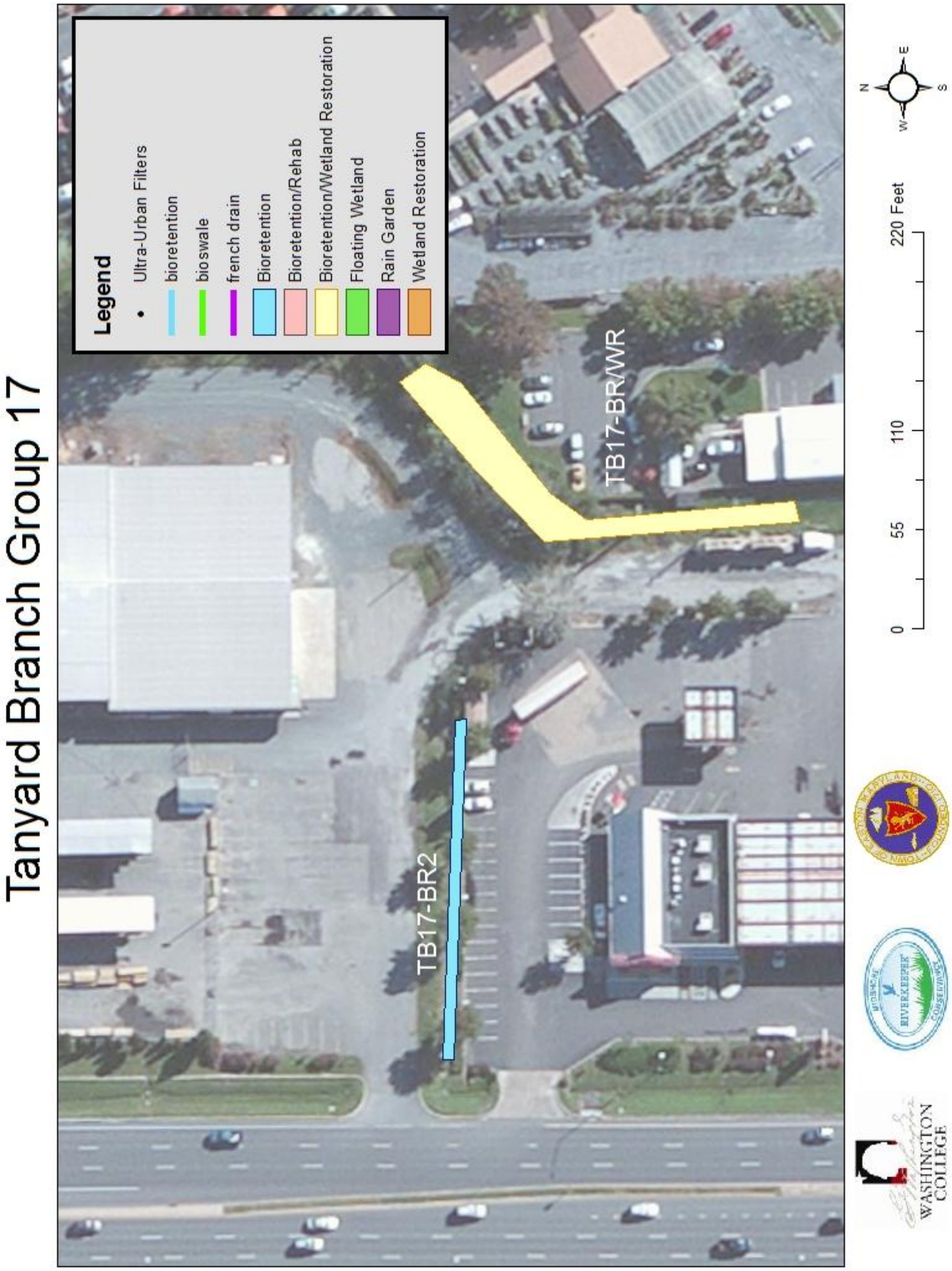
Cost: **$27,500- $67,000**

Priority: **2**

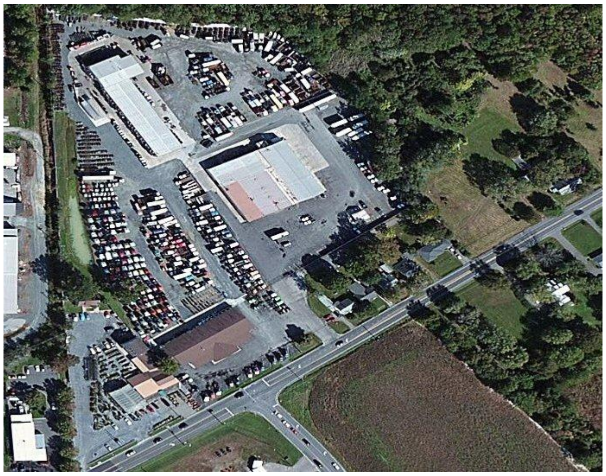
Site Name	Location	Practice	Size of practice	Cost (low)	Cost (high)	N Reduction (lbs)
TB17-BR/WR	Sunoco	bioretention/wetlands	4,300 sf	$21,500	$51,600	25
TB17-BR2	Sunoco	bioretention	1200 sf	$6,000	$14,400	

TB17: **Sunoco station.** This location provides an additional opportunity to provide treatment to approximately one acre of impervious surface with no current stormwater management in place. In addition to the bioretentions in the SHA right of way (TB15-SHA-BR8, 9, &10), we recommend several small bioretentions within the grassy areas on this property to slow and filter water leaving this filling station.

TB17 Sunoco Station



TB18 LKQ Trucks



Retrofits: **1**

Watershed Size: **7.0 acres**

Cost per lb: **$784-$1882**

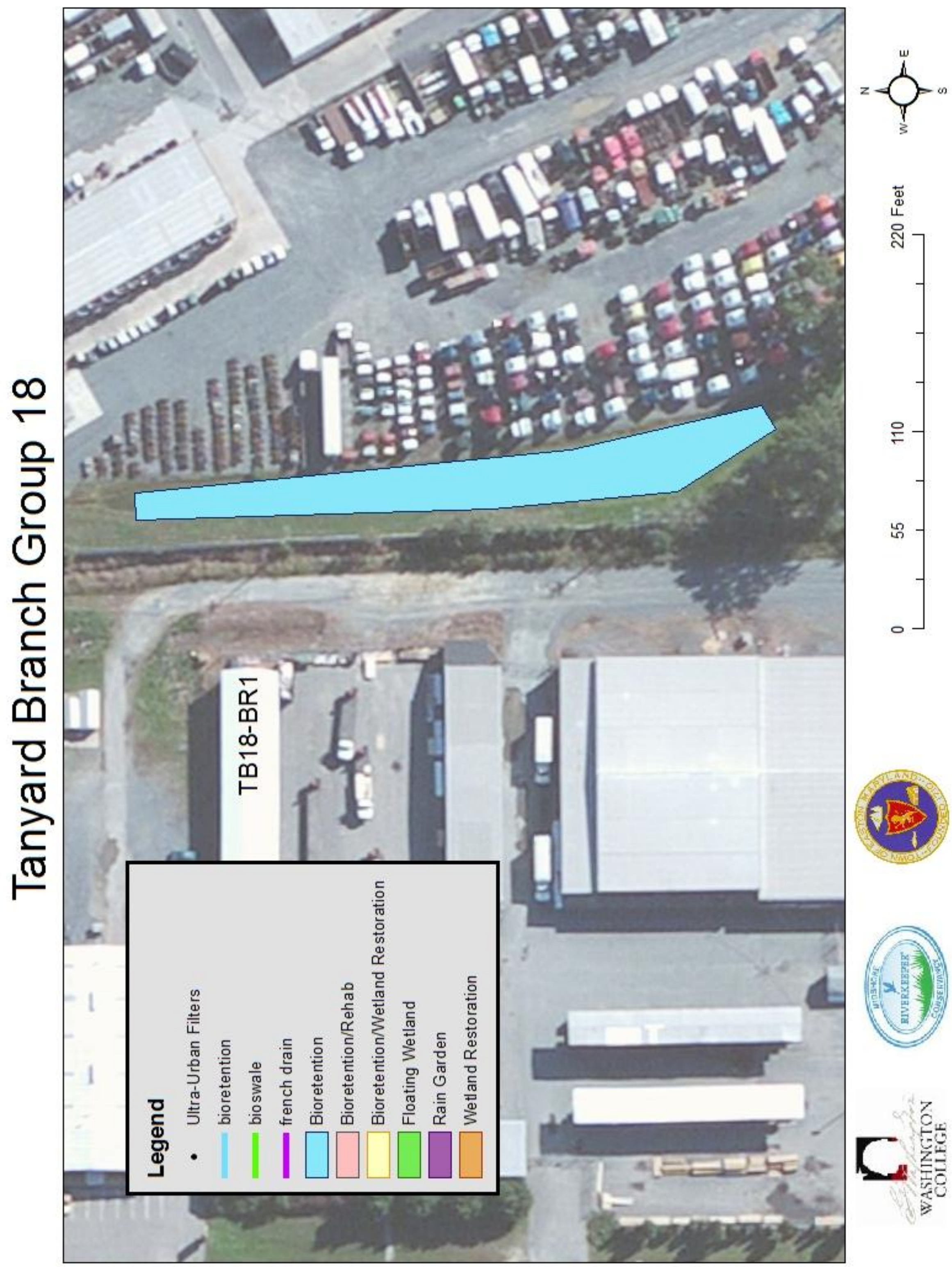
Cost: **$45,000-$108,000**

Priority: **2**

Site Name	Location	Practice	Size of practice	Cost (low)	Cost (high)	N Reduction (lbs)
TB18-BR1	Tractor truck yard	bioretention	9,000 sf	$45,000	$108,000	57

TB18: LKQ Trucks and Transaxle: Two businesses occupy this location in the watershed. There are approximately 8.2 acres of impervious coverage on these properties with no existing stormwater management. Much of the property drains towards the area where we recommend a large bioretention cell.

TB18 LKQ Trucks



TB19

Retrofits: **3**

Watershed Size: **2.4 acres**

Cost per lb: **$1412-$3350**

Cost: **$27,400-$65,400**

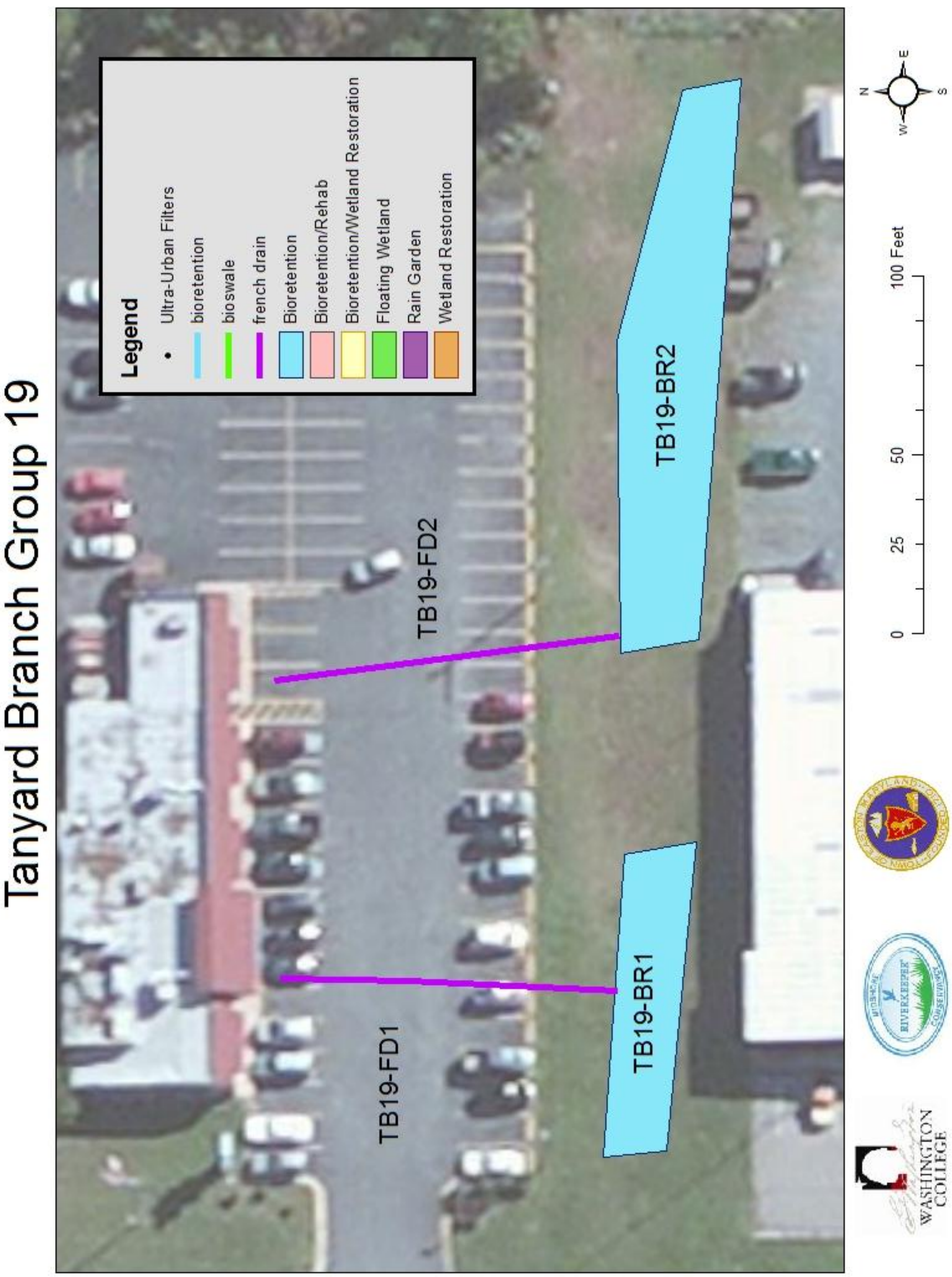
Priority: **2**

Retrofit Code	Owner Name Line 1	Account ID
TB19-BR1	Barnard Properties Partnership	2101050354
TB19-BR2	Barnard Properties Partnership	2101050354
TB19-FD1	Ambell, James E.	2101056034
TB19-FD1	Barnard Properties Partnership	2101050354
TB19-FD2	Ambell, James E.	2101056034
TB19-FD2	Barnard Properties Partnership	2101050354

Site Name	Location	Practice	Size of practice	Cost (low)	Cost (high)	N REduction (lbs)
TB19-BR1	South of Easton Diner	bioretention	1,600 sf	$8,000	$19,200	19
TB19-BR2	South of Easton Diner	bioretention	3,800 sf	$19,000	$45,600	
TB19-FD	Easton Diner lot	French drain	200 lf	$400	$600	

TB19: This site is located between the Easton Diner and Easton Auto Care. The area identified for two bioretetion cells is currently a grassy area that conveys water to a ditch located east of the property. This is an ideal location for a practice that would offer an opportunity to slow and filter water running off of large impervious areas before it gets to a direct conveyance to Tanyard Branch. In addition, French drains would need to be constructed across the Easton Diner parking lot to drain water to the practice.

TB19


Tanyard Branch Group 19
Legend
Ultra-Urban Filters
bioretention
bioswale
french drain
Bioretention
Bioretention/Rehab
Bioretention/Wetland Restoration
Floating Wetland
Rain Garden
Wetland Restoration
TB19-BR2
TB19-FD2
TB19-BR1
TB19-FD1
0
25
50
100 Feet
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E
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WASHINGTON COLLEGE
RIVERKEEPER

TB20 Ultra Urban Filters-Goldsborough Street

Retrofits: **Approx. 32**

Watershed Size: **147.9 acres**

Efficiency: remove 80% of TSS and 95% of hydrocarbons

Cost: **$50,000-$59,400**

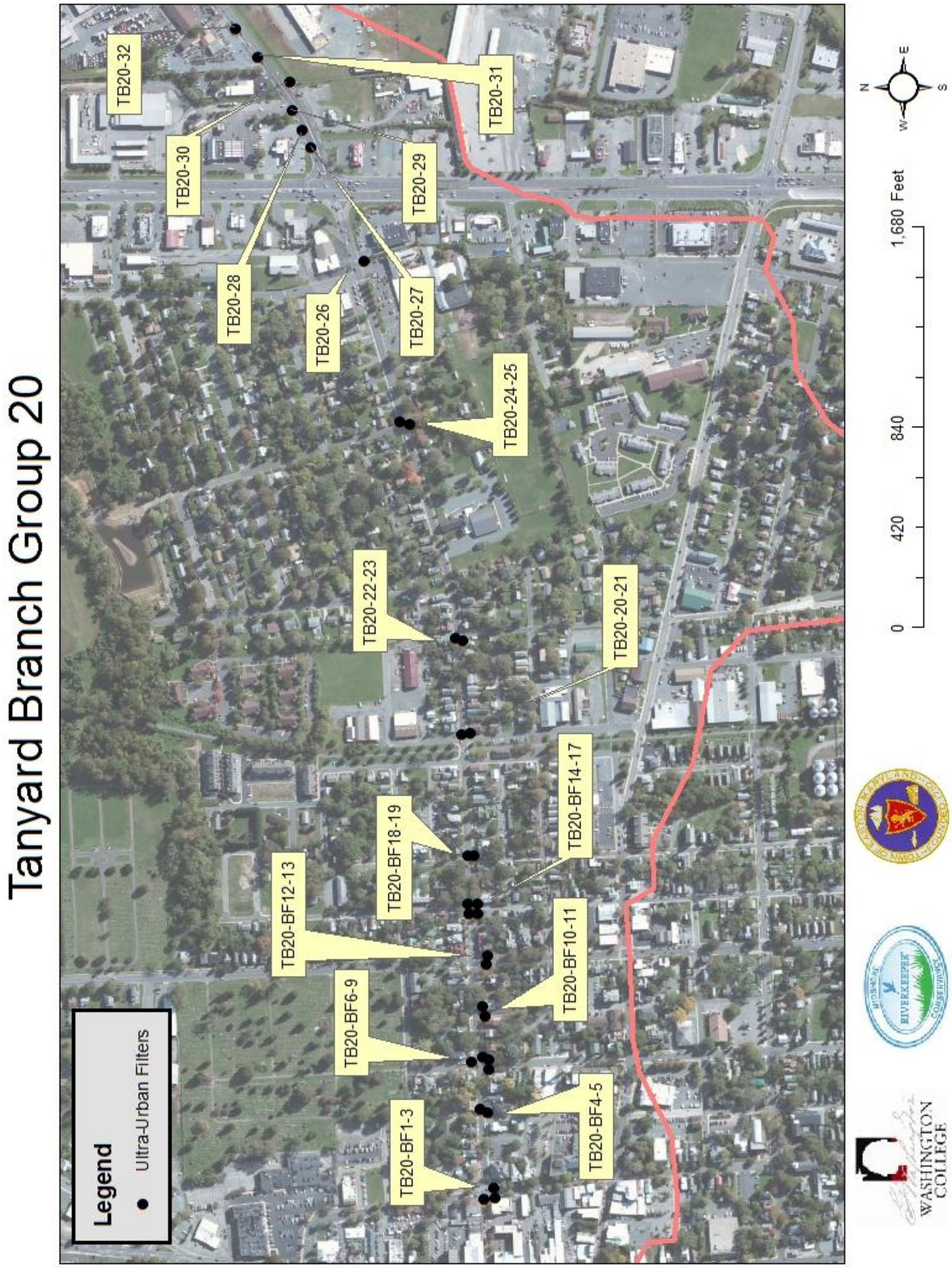
Priority: **2**

Site Name	Location	Practice	Size of practice	Cost (low)	Cost (high)	N Reduction (lbs)
TB20-BF	Goldsborough St curb inets	ultra-urban filters	32	$50,000	$59,400	

TB20: The project team recommends placing filters in storm drain inlets along the heaviest travelled roads in the watershed, U.S. 50 and Goldsborough Street. Washington College GIS lab identified 247 curb inlet structures. We recommend fitting the 32 inlets on Goldsborough and 13 inlets on U.S. 50 with Abtech Industries Ultra-Urban Filter with smart sponge. These products are efficient at filtering runoff to remove Total Suspended Solids (TSS), phosphorus, metals and hydrocarbons. In addition, the filters break down the hydrocarbons and contain them so that when the filters are changed, the old ones can be disposed of in a standard landfill without being treated as hazardous waste.

The Project Team did consider the Filterra Bioretenion Systems; however the team felt that when looking at a cost vs. efficiency basis, the ultra-urban filters are easier. The Filterra may be a good practice where a roadway is undergoing construction though. More information on the Filterra can be found at http://www.filterra.com/.

TB20 Ultra Urban Filters- Goldsborough



TB21 Comfort Inn

Retrofits: **1**

Watershed Size: **1.8 acres**

Cost per lb: **$65-$128**

Cost: **$1,200-$2,400**

Priority: **2**

Site Name	Location	Practice	Size of practice	Cost (low)	Cost (high)	N Reductin (lbs)
TB21-BS1	south Comfort Inn	bioswale	600 sf	$1,200	$2,400	19

TB21: Comfort Inn: This project offers an opportunity to provide treatment to half the parking area in this hotel complex. A 200 linear foot bioswale would provide additional treatment to a relatively large area of impervious.

TB21 Comfort Inn

TB22 Tree Canopy

Retrofits: N/A

Watershed Size: N/A

Cost per lb: N/A

Site Name	Location	Practice	Size of practice	Cost (low)	Cost (high)	N Reduction (lbs)
TB22	tree plantings	urban tree canopy	N/A	N/A	N/A	N/A

TB22 23% of the watershed is shielded by tree canopy. This is very low and we recommend, as part of these restoration efforts a goal of increasing the tree canopy to 40% of the watershed. A large tree can pull up to 500 gallons of water a day from the groundwater, and its canopy can prevent a large percentage of rainfall from hitting the ground. If this practice were implemented, it offers a means to reduce the flashiness of Tanyard Branch.

4.3 Discussion

Very high impervious coverage, the channelization of the stream, loss of wetlands, and loss of floodplain has heavily impacted the Tanyard Branch watershed. As a result of the high impervious coverage and extensive storm drain network, the stream is extremely flashy. It receives a large percentage of its flows during heavy rain events and otherwise maintains base flow conditions averaging 0.51 cubic feet per second (cfs). Storm flows have been measured at 80 cfs immediately following a 1/2" rain event. The stream acts like a storm sewer, conveying stormwater from the Town of Easton down to the Tred Avon River and carries with it nutrients and any oil and grease that may have been deposited on the impervious surfaces. See Figure 6 below that characterizes stream health relative to impervious coverage.

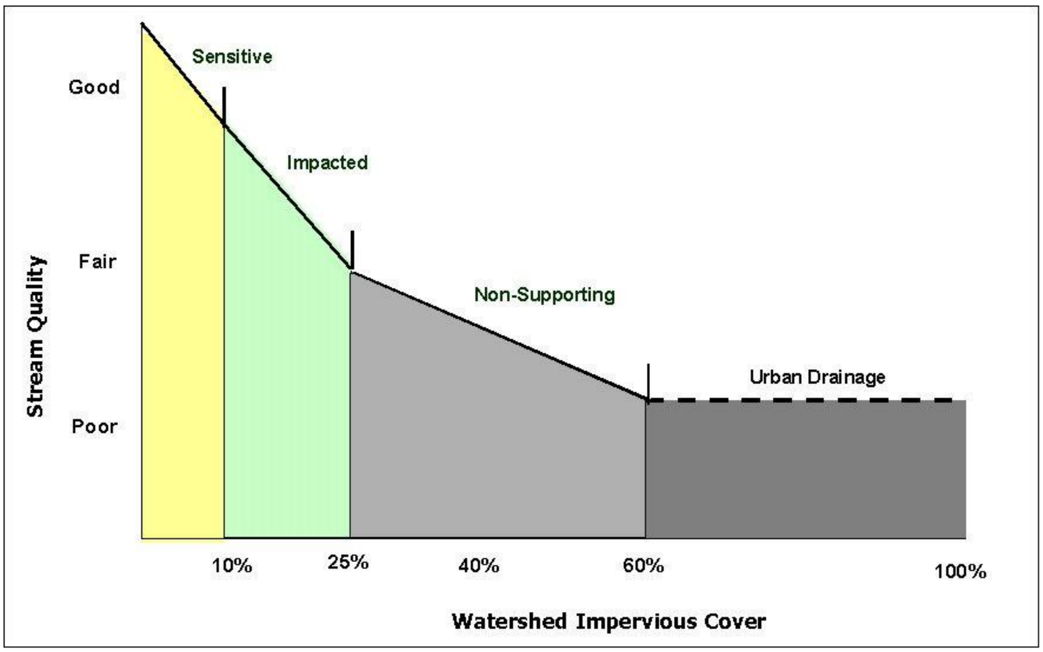


Figure 6. Tom Schueler developed this impervious coverage model that characterizes stream health relative to impervious coverage.

High concentrations of hydrocarbons are washed off of roadways and parking lots. Hydrocarbons are toxic at very low concentrations to aquatic macroinvertebrates and move through the food chain readily. To counteract the accumulation of hydrocarbons in local receiving waters, we recommend installing ultra-urban filters with a smart sponge in curb inlets and at grade inlets, where possible. These filters are relatively inexpensive but must be replaced every two to three years. They are designed to function while allowing 300-600 gallons of water per minute to pass through and thus will not cause or contribute to flooding.

It may be impossible to increase the diversity of fish, insects, and animals in a polluted heavily urban stream. However, if the retrofit projects we recommend are installed and maintained over time, we may achieve a substantial decrease in pollution loads to the Tanyard Branch. We would also realize improvements to the North Fork of the Tred Avon River.

With the exception of the floating wetlands, the recommended BMP's are all accepted by the U.S. Environmental Protection Agency's Chesapeake Bay Program, and we anticipate that floating wetlands will be added to this list when it is next updated in 2017.

Priority Projects

The top priority projects are the floating wetlands and aerators in the two Bay Street Ponds (TB 5 and TB 6,) and TB15, a network of bioretention cells, bioswales and storm drain filters along the U.S. Route 50 corridor within the State Highway Administration (SHA) right of way. The floating wetlands are the only in-stream practices we recommend and they will function to actively remove nitrogen and phosphorus directly from the water before they can be taken up by algae. Research conducted by Dr. Andrew Lazur and Jeff Cornwell at UMCES Horn Point Lab, verifies the dramatic impacts this practice can have on water quality in ponds that discharge to tidal and non-tidal waters. The combination of an aerator beneath the floating wetlands and the floating wetlands themselves serves to release nutrients from the bottom sediments and enables the floating wetland to absorb and assimilate them. The floating wetlands will also uptake nutrients as they move through the stream system. If these projects are installed as recommended they are estimated to remove 1,000 pounds of nitrogen per year at a one-time cost of $48/lb. plus minor maintenance costs each year.

Ron Flohr, the president of the Waterfowl Festival which owns the ponds, is receptive to the concept and even the possibility that the Waterfowl Festival might be a financial supporter of such a project. Once the floating wetlands are installed, we recommend targeting projects from the very high priority list and then working through the high priority and finally the medium priority.

Our team's water quality analysis identified the portion of Tanyard Branch immediately downstream from U.S. 50 as a hotspot, with very high nitrogen loads and very high Total Suspended Solids (TSS). If SHA were to implement the recommended projects, it would be possible to reduce the loading and extremely high stream flows generated by this highly developed portion of the watershed.

Recommended Projects

The over-arching goal of the remainder of the recommended projects is to slow and filter stormwater before it reaches the Tanyard Branch. Most of our recommendations are designed to provide treatment to the large parking lots, roadways and commercial areas within the watershed. The net improvements to water quality will be realized incrementally as each project in this list is implemented. Other than the floating wetlands, all the recommended practices rely on some form of a bioretention facility (see schematic in Figure 7.) Bioretention facilities are designed to function in much the same way processes occur in the natural environment. In fact, it is this principal of following the physical, chemical and biological processes that occur in nature that we are attempting to reproduce. Depending upon the design of a facility, different processes can be maximized or minimized with respect to the type of pollutant loading expected.

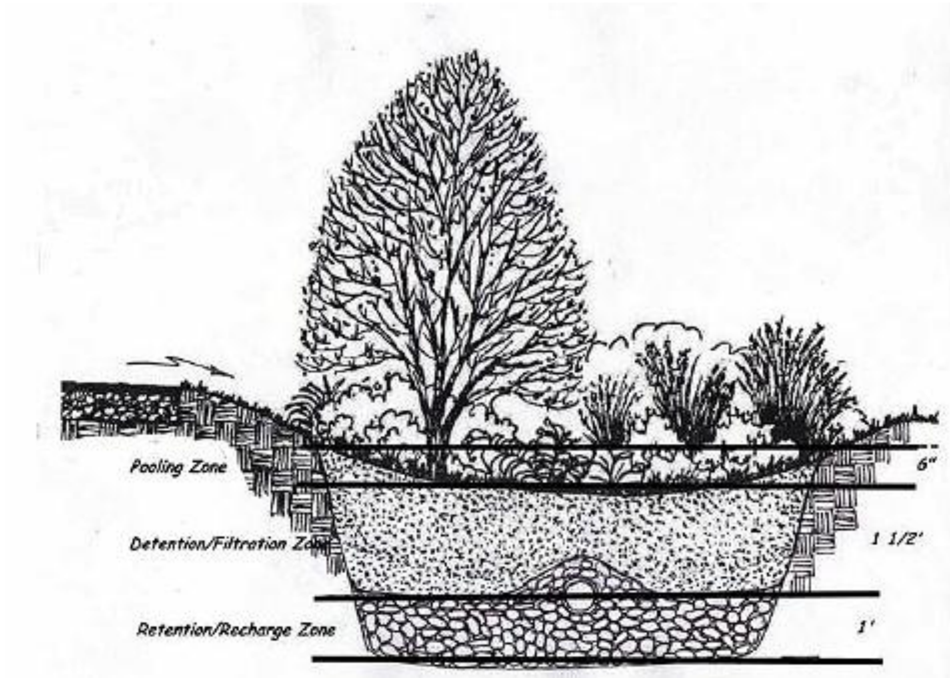


Figure 7. A schematic of a bioretention cell. This report recommends bioretention as the primary method for retrofit because of the way these practices mimic natural processes. For more information about bioretention, see Appendix Section 10.2.

4.4 Identified Critical Habitat and Land Use Areas

In addition to the fieldwork and sampling we have identified severe erosion around a sanitary sewer pipe and a possible wetland restoration location. We have identified and prioritized candidate restoration projects (e.g., floating wetlands, wetland restoration, bioretention facilities, etc.) We have identified maintenance concerns such as failing infrastructure, and non-tidal wetlands that have been filled without a permit.

The town-owned RTC Park property offers an excellent opportunity to restore at least 11 acres of non-tidal wetlands (see TB8, above) and to expand the buffer to Tanyard Branch with tree planting. Non-tidal wetlands perform critical functions to ecosystem processes including flood storage and attenuation, provide excellent habitat value and process nutrients very efficiently. This project should be considered a high priority based on the very low cost and the fact that the town owns the property. The areas identified for wetland restoration are mapped with hydric soils and exhibit characteristics consistent with wetland hydrology. To restore these areas to forested wetlands would involve identifying the boundaries and planting wetland vegetation. This area was previously identified as a priority project for the US Army Corps of Engineers in 2002. The project was cancelled because it was not funded.

MRC and CES conducted an assessment of conditions in the upland portions of the watershed and evaluated land use and concurrent pollution-producing behaviors and conditions. This assessment identified areas outside the stream corridor where pollution reduction possibilities exist, and evaluated sites for field investigation that might aid upland restoration and stormwater retrofit opportunities. Analysis of the various GIS layers developed as part of the project revealed targeted areas of interest, which were then verified with fieldwork.

4.5 Costs to Implement Load Reductions

We have attached cost estimates to each management measure in the prioritized list identified in Table 7. We estimate that the low range for implementing all of our recommended projects is $640,410 and the high range is $1,341,450. Potential sources of funding include:

Funder	Maximum grant available
National Fish and Wildlife Foundation	$200,000
Chesapeake Bay Trust	$50,000
Environmental Protection Agency	$1,000,000
Waterfowl Festival-Ron Flohr	Receptive to floating wetlands and potential financial assistance
State Highway Administration Transportation Enhancement Program	$675,000 with 50% match requirement

4.6 Outreach/Education Component

We developed a brochure (Appendix Section 10.6) for residents and property owners of the Tanyard Branch to inform them of the results of the study and to educate stakeholders about the watershed and positive steps they can take to reduce pollution from their residence/business/farm. This will also be used to advertise the final stakeholder meeting during which we hope to get a large turnout from the community.

4.7 Schedule for Implementation

We developed a schedule for implementation for the management goals. This timetable can easily be revised based on conversations with the Town of Easton and their goals and fundraising for project implementation. A tentative timetable has been created that spreads the projects over a 7 year time frame, which will help the Town of Easton meet its WIP goals.

Table 8. Tentative timetable for project implementation.

Project	2013	2014	2015	2016	2017	2018	2019	2020	2021
TB5	x								
TB6	x								
TB1		x							
TB2		x							
TB3			x						
TB15			x						
TB4			x						
TB8				x					
TB10				x					
TB11					x				
TB12					x				
TB14						x			
TB7						x			
TB9							x		
TB16							x		
TB17								x	
TB18								x	
TB19								x	
TB20									x
TB21									x
TB22	x	x	x	x	x	x	x	x	x
TB13	x	x	x	x	x	x	x	x	x

4.8 Milestones to Assess Progress towards Goals

We will develop a list of two-year milestones with the Town of Easton that will enable the Town and stakeholders to have real, attainable short-term goals while working towards the larger picture of reducing loading rates to Tanyard Branch. This list will also be included in the final report.

4.9 Nutrient Reduction Tracking

Each retrofit project has an assigned efficiency. Once the Town of Easton chooses which projects to implement and when, MRC is available to initiate a simple monitoring program at site TB5 to quantify the reduction of nutrient loads. The costs for conducting such a program would be the time for an MRC employee to go out in the field, take samples, deliver them to the University of Maryland's Horn Point Lab, the lab's charge for nutrient analysis (nitrogen and phosphorus), and MRC's evaluation of the results and communication of the results to the Town of Easton   The current suggestion would be to collect samples after implementation of retrofits from site TB5, which gives a good indication of the health of the entire watershed. Although, depending on implementation of retrofits sampling can be adjusted accordingly.

Object	Cost
MRC time & travel per sample collection	$175
Nutrient Analysis	$24/sample

5.0 Stakeholder Engagement

The project team worked with the Town of Easton to schedule stakeholder meetings as the project progressed. One meeting was held on August 9th, 2012, at a local Fire Hall. To advertise this meeting, the Town of Easton mailed a notice to every property owner in the watershed. The Project Team prepared an informational flyer on some steps that private property owners could take on their own to improve water quality in the watershed and this was included in the notice.

About 20 citizens showed up for this meeting which covered some of the preliminary results of the Project Team. Feedback from the participants was valuable and some questions about initial data results were very helpful. There was at least one comment or concern about how much these changes would cost, and if private property owners would be required to pay for these retrofits on their own properties. They were assured that there was no plan in the works that would require private property owners to pay for any retrofits.

6.0 Presentation of Draft Plan to Town of Easton

The Draft Plan will be presented to the Town of Easton at the Planning Commission meeting in December.

7.0 Publication of Final Plan

The project team will deliver all materials used for the project to the town in an electronic format to include well-organized GIS files, test results, tables, and any other products derived from the assessment and planning process.

8.0 Timeline

Task	Feb 2012	Mar	Apr	May	June	Jul	Aug	Sep	Oct	Nov	Dec	Jan 2013
Assessment												
Stakeholder Engagement												
Draft Plan												
Draft Plan Presentation												
Final Plan Presentation												

9.0 Literature Cited

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10.0 List of Appendices

10.1 GIS Analysis

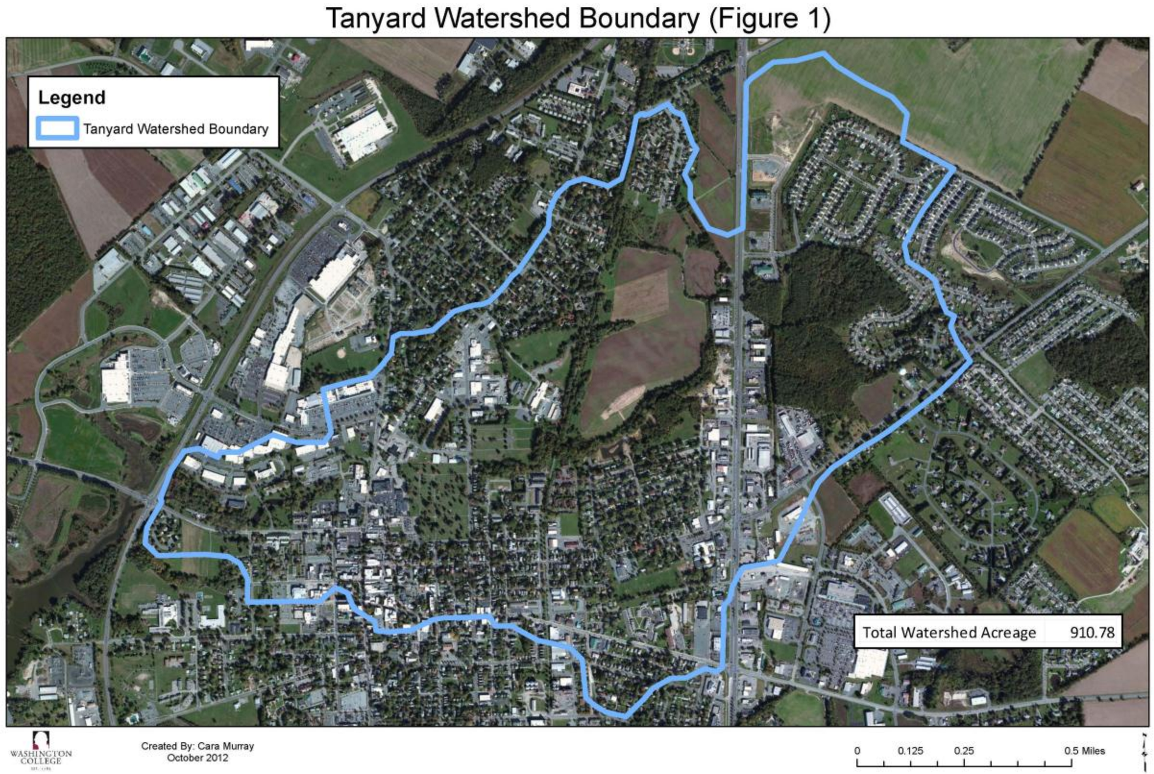


Figure 1: Watershed Boundary
This map shows the outline of the watershed boundary which is calculated to contain 910.78 acres.

Tanyard Watershed Digital Elevation Model (Figure 2)

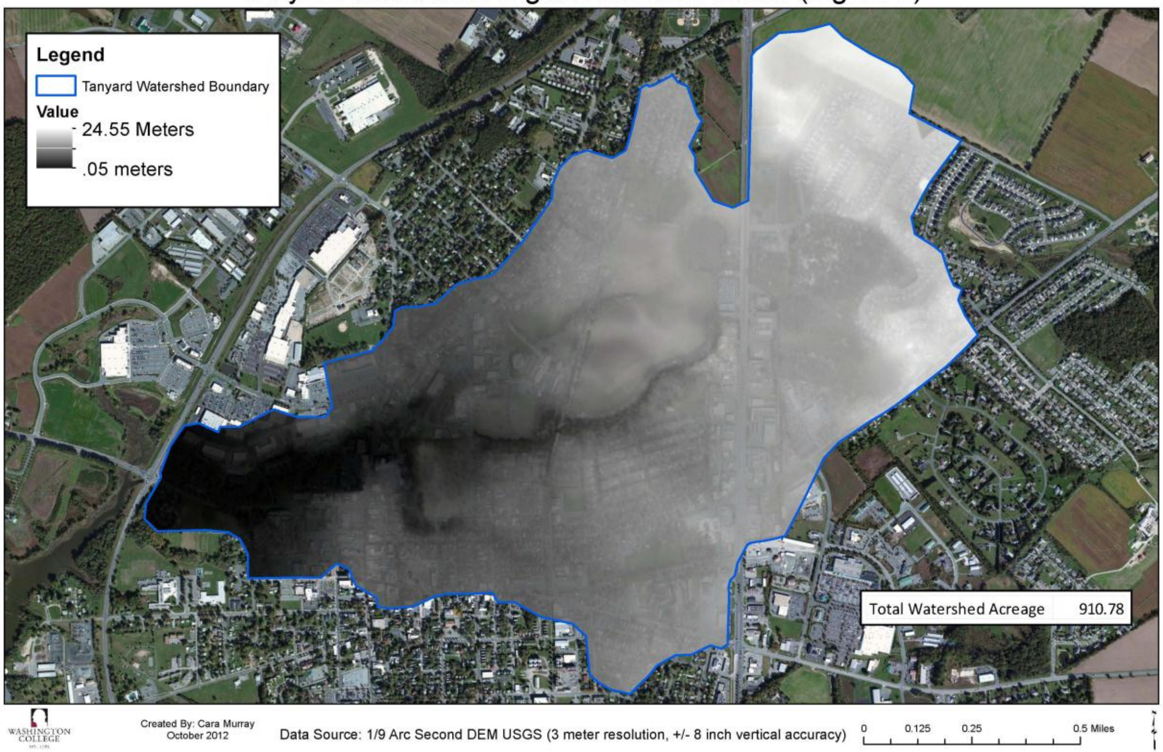


Figure 2: Digital Elevation Model (DEM)

To complete this analysis we utilized the 1/9 Arc Second DEM USGS (3 meter resolution) data clipped to the Tanyard Watershed Boundary. The vertical accuracy of this data is +/- 8 inches and is a derivative product of the LIDAR data acquired by the Maryland Department of Natural Resources. The low elevation was 0.05 meters and the highest point was 24.55 meters.

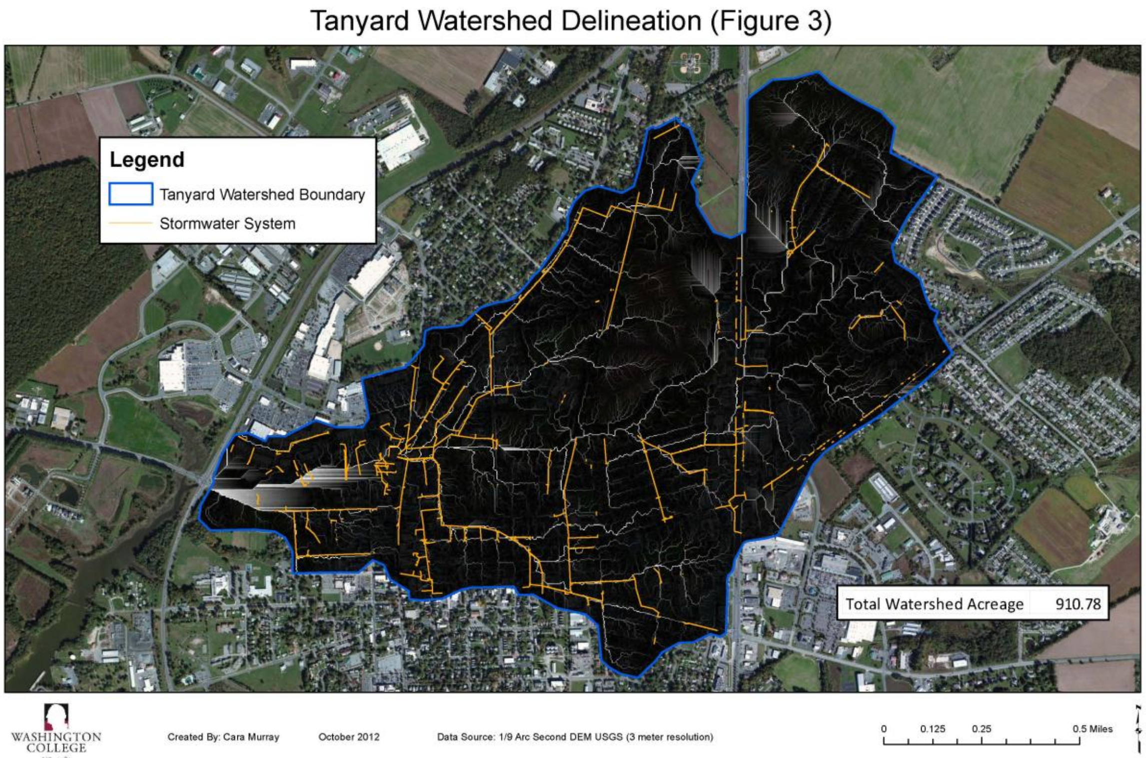


Figure 3: Watershed Delineation
Using the GIS data from DEM found in Figure 2, this data was then converted to a flow length map using ArcMap tools. By examining the hydrologic flow lines from the origination point we traced the outline of the watershed boundary. To assist in the delineation of this analysis the Tanyard Stormwater System was added to this map so it could be seen where manmade stormwater lines impacted the natural flow of water. The boundary was adjusted accordingly.

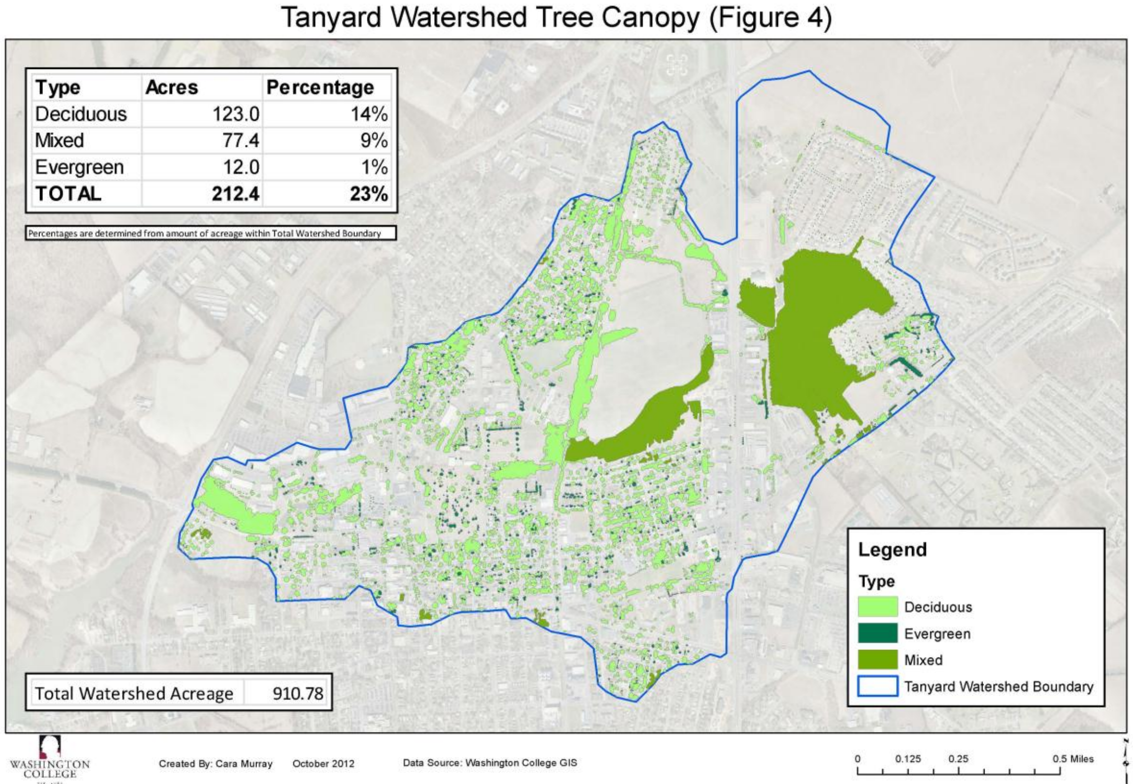


Figure 4: Tree Canopy
This layer was digitized by a using a visual assessment of aerial imagery from several sources such as county imagery from 2004 and 2008, and Near IR imagery from USDA NAIP, along with multispectral imagery from Digital Globe WorldView II. The tree canopy coverage attributed to be one of three types: deciduous, evergreen or mixed. Once the digitizing was complete, the data was clipped to the Tanyard Branch Watershed Boundary; then each type of canopy coverage was analyzed to determine acreage and percentage of watershed covered.

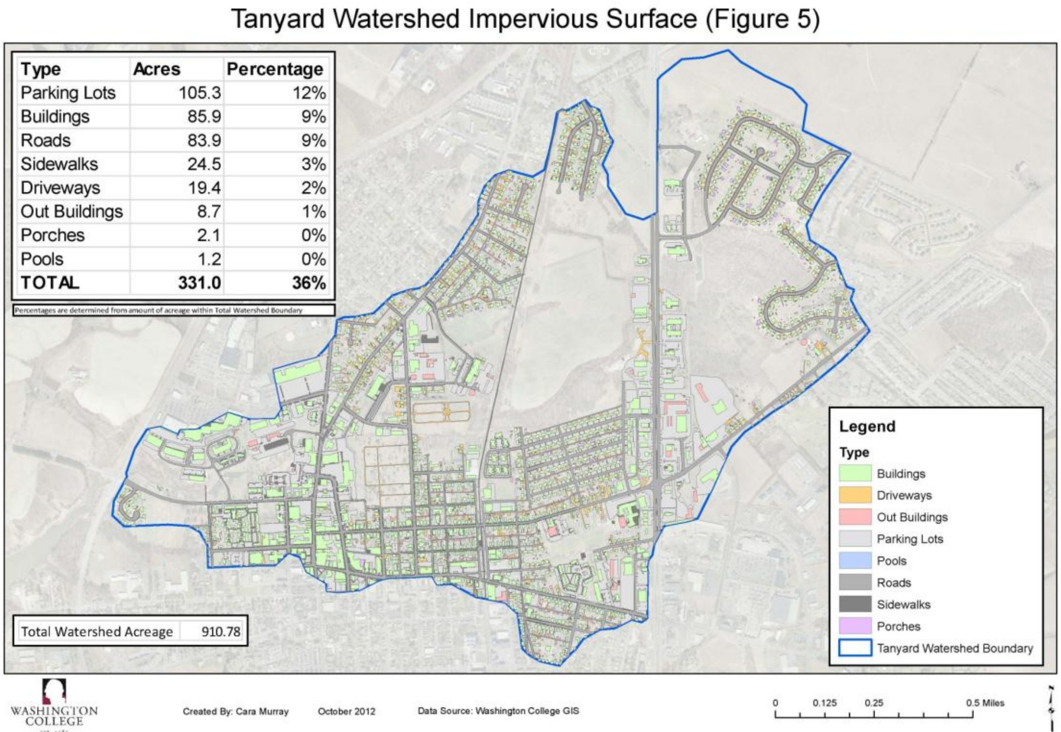


Figure 5: Impervious Surface
The impervious surfaces layer was digitized using a visual assessment of the aerial imagery, and was classified into eight separate categories. Once the digitizing was complete, the data was clipped to the Tanyard Branch Watershed Boundary; then each type of impervious surface was analyzed to determine acreage and percentage of watershed covered.

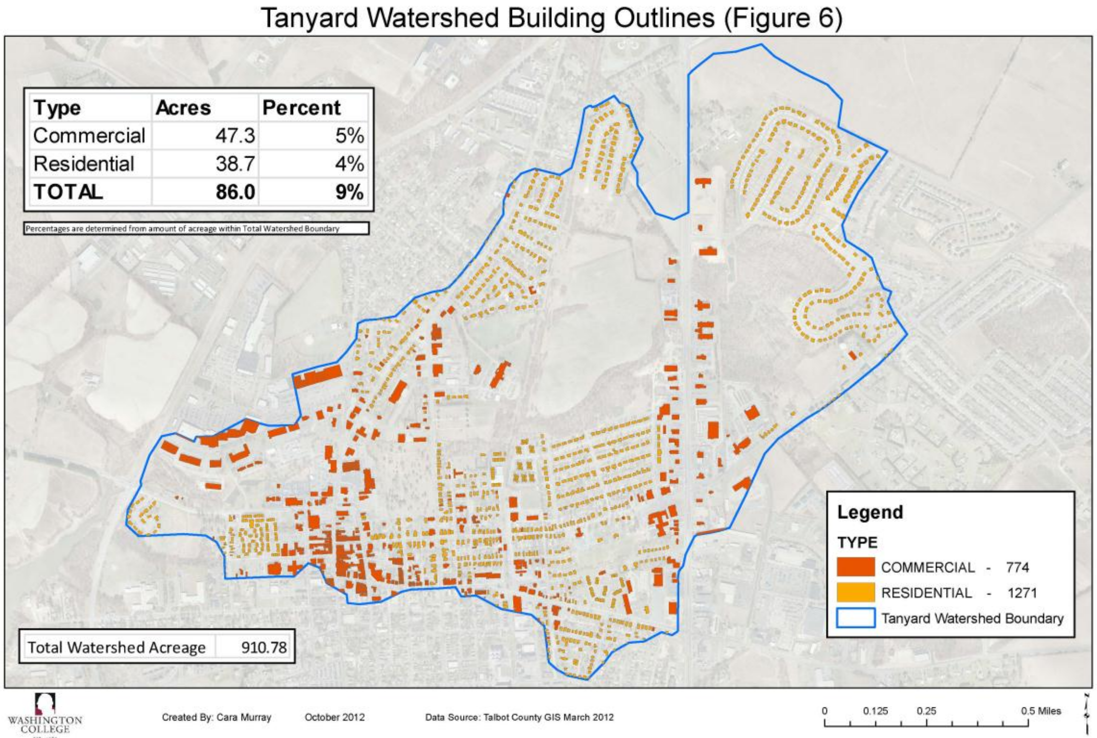


Figure 6: Building Outlines
The Talbot County GIS Buildings data were clipped to the Tanyard Watershed Boundary. The data was then divided into three types: commercial, no building and residential. The building land cover was then analyzed by determining the amount of acres covered by each type of building and then using that statistic to determine the percentage of watershed those types of buildings covered.

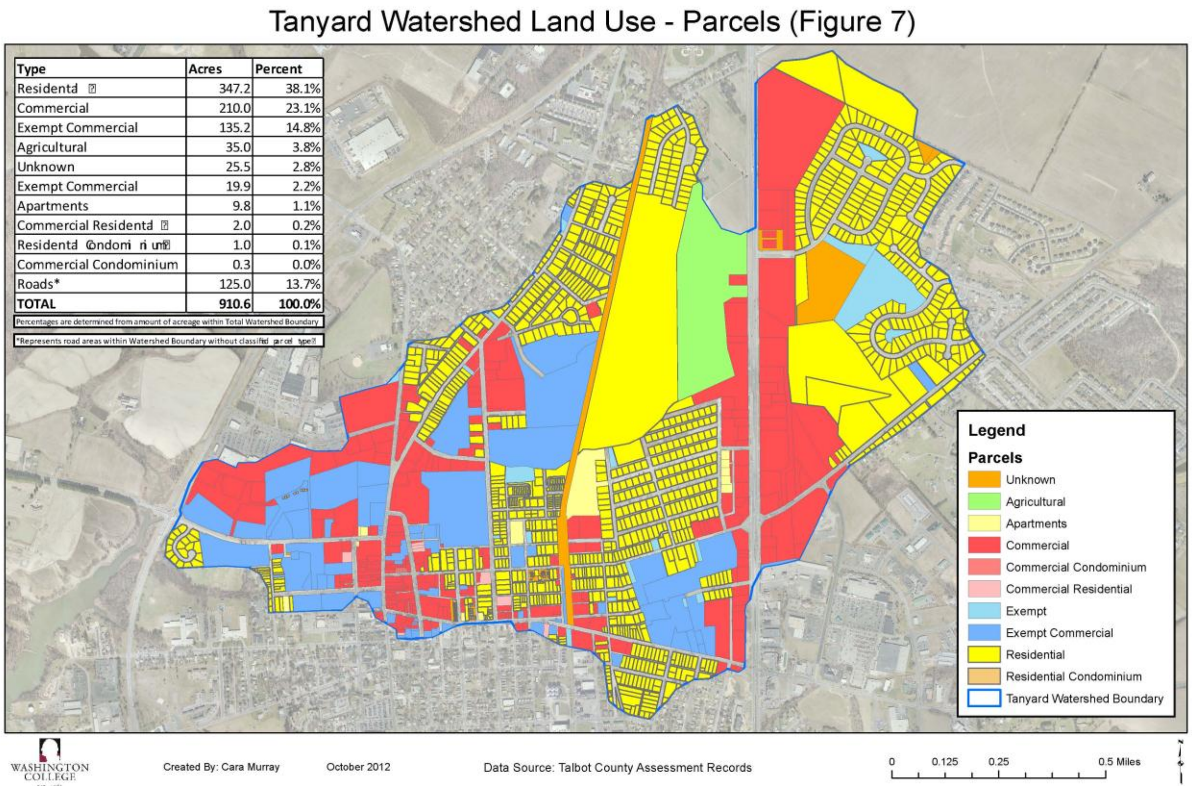


Figure 7: Land Use – Parcels
Using GIS data obtained from Talbot County the parcels were classified into ten categories. The data was clipped to the Tanyard Branch Watershed Boundary and then each type of parcel was analyzed to determine acreage and percentage of watershed covered.

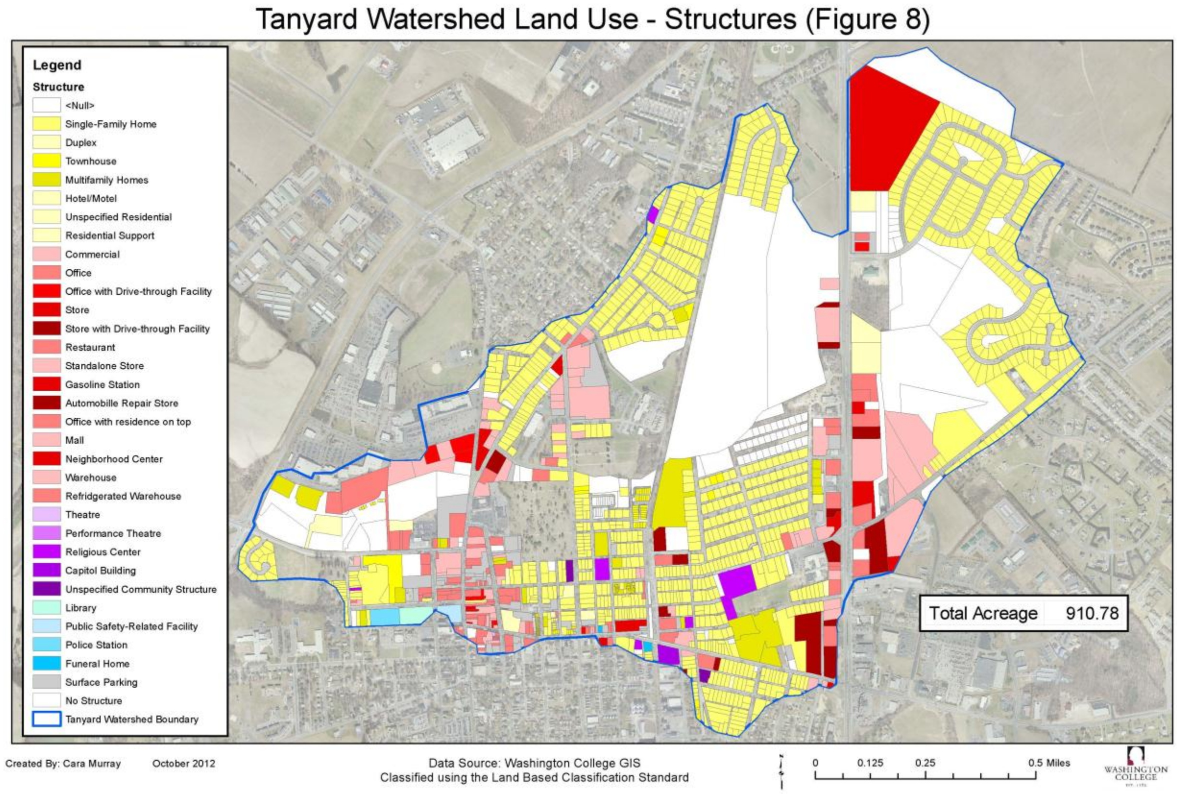


Figure 8: Land Use – Structures
Using the parcel data obtained from Talbot County as a base map the staff utilized the American Planning Association Land Based Classification Standard to classify each parcel for Activity, Function, Structure, Site, and Ownership. This map shows the structure analysis.

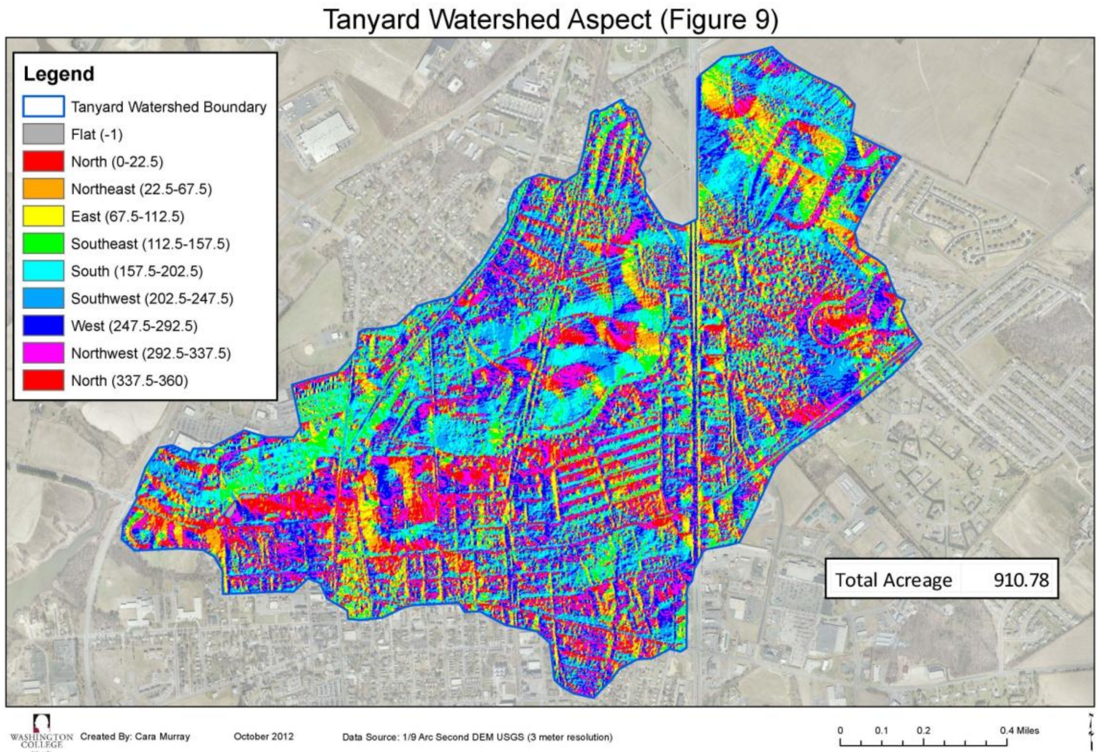


Figure 9: Aspect
To determine Aspect the staff utilized 1/9 Arc second DEM USGS (3 meter resolution) data clipped to the Tanyard Watershed Boundary. The DEM data was then converted to an aspect analysis using ArcMap tools.

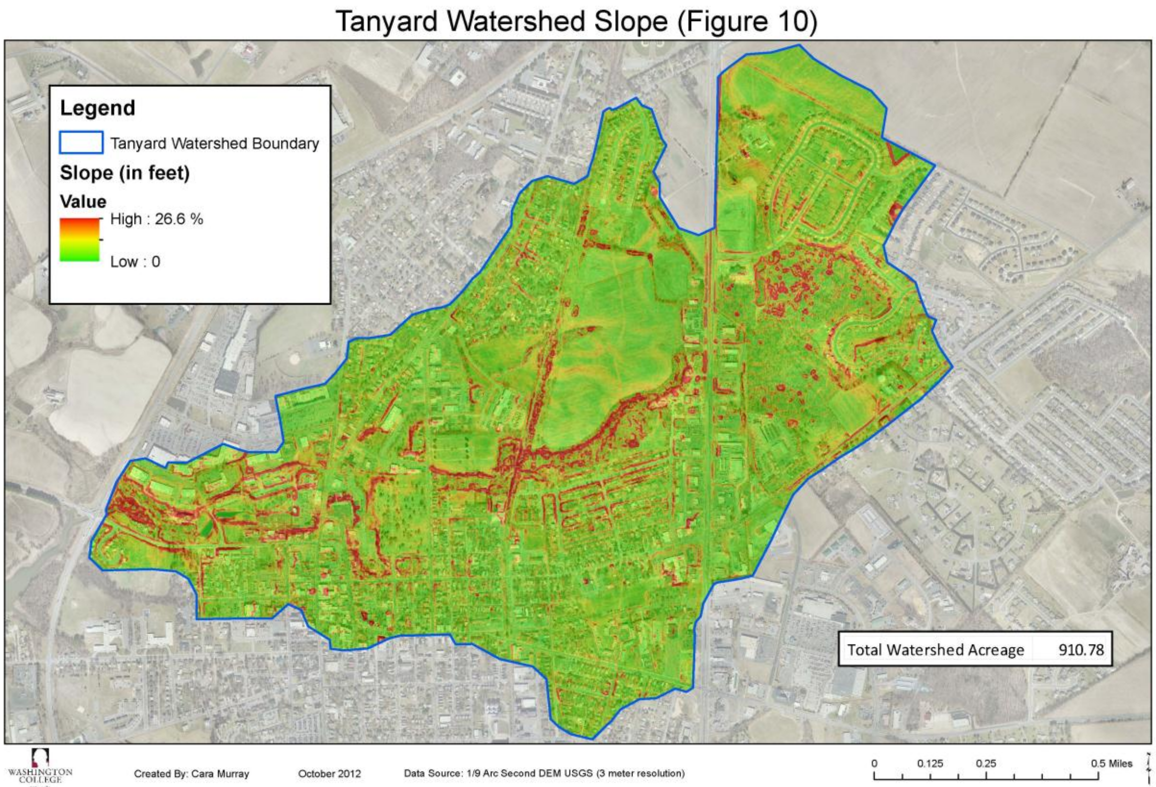


Figure 10: Slope
To determine Slope the staff utilized 1/9 Arc second DEM USGS (3 meter resolution) data clipped to the Tanyard Watershed Boundary. The DEM data was then converted to a slope analysis using ArcMap tools.

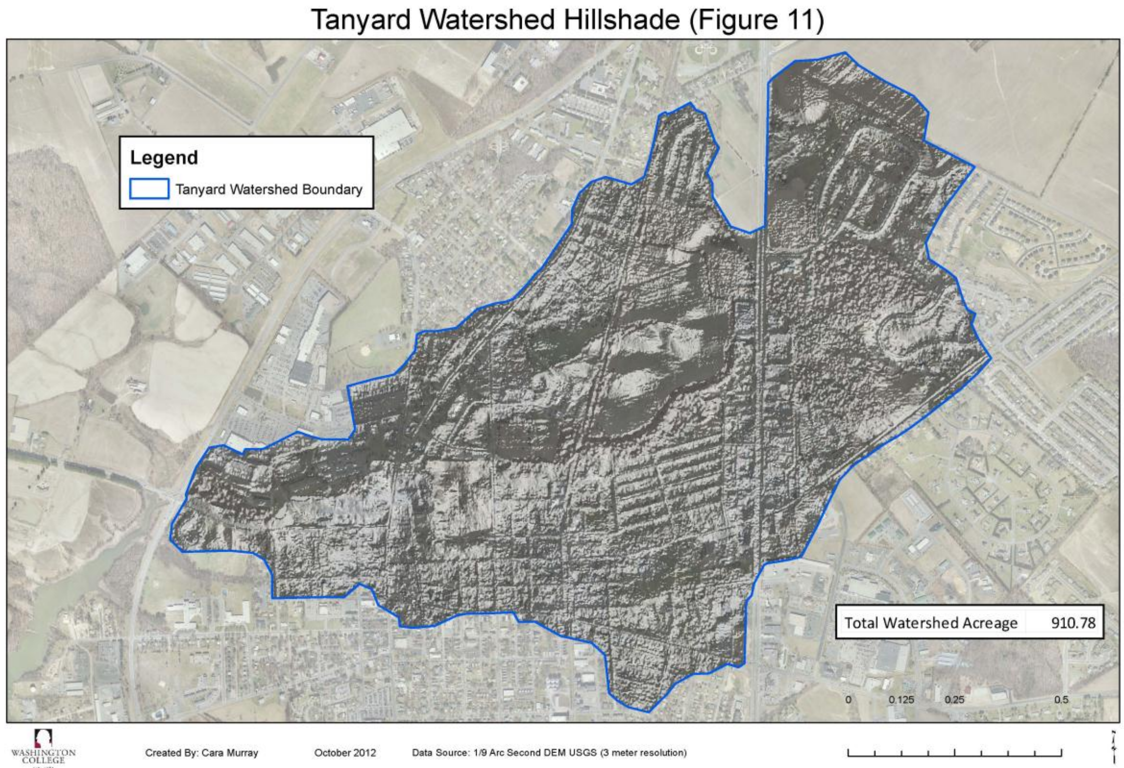
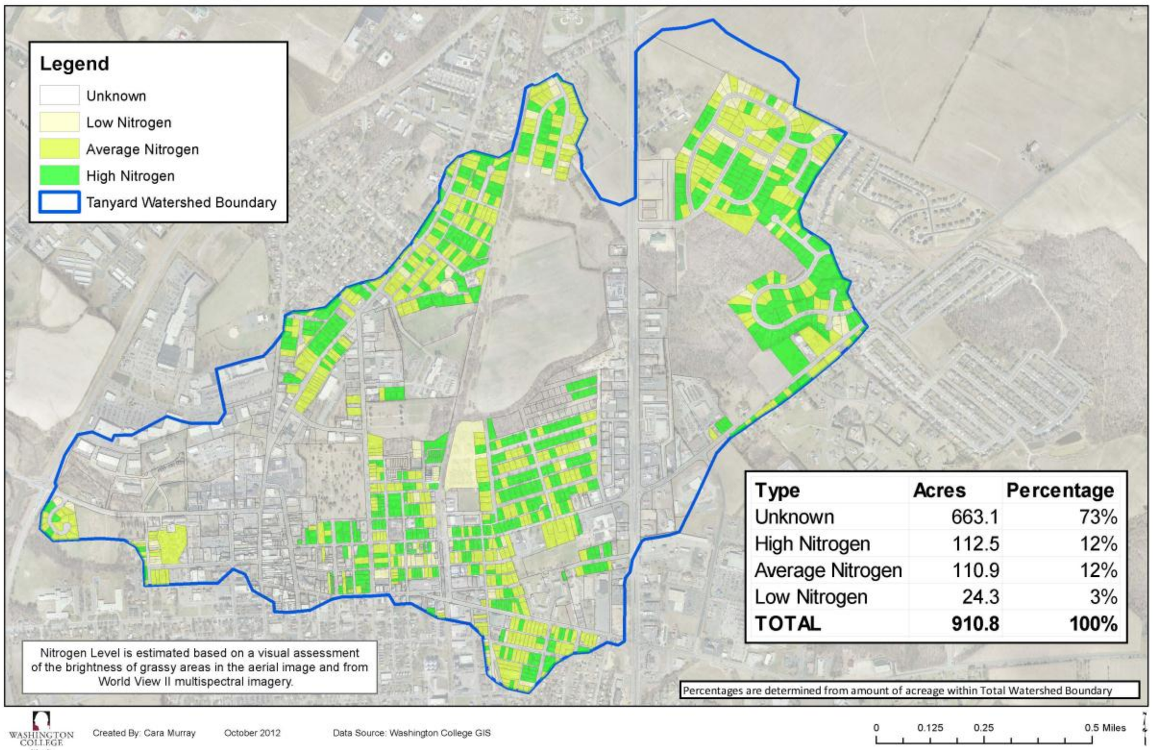


Figure 11: Hillshade
To determine Hillshade the staff utilized 1/9 Arc second DEM USGS (3 meter resolution) data clipped to the Tanyard Watershed Boundary. The DEM data was then converted to a hillshade analysis using ArcMap tools.

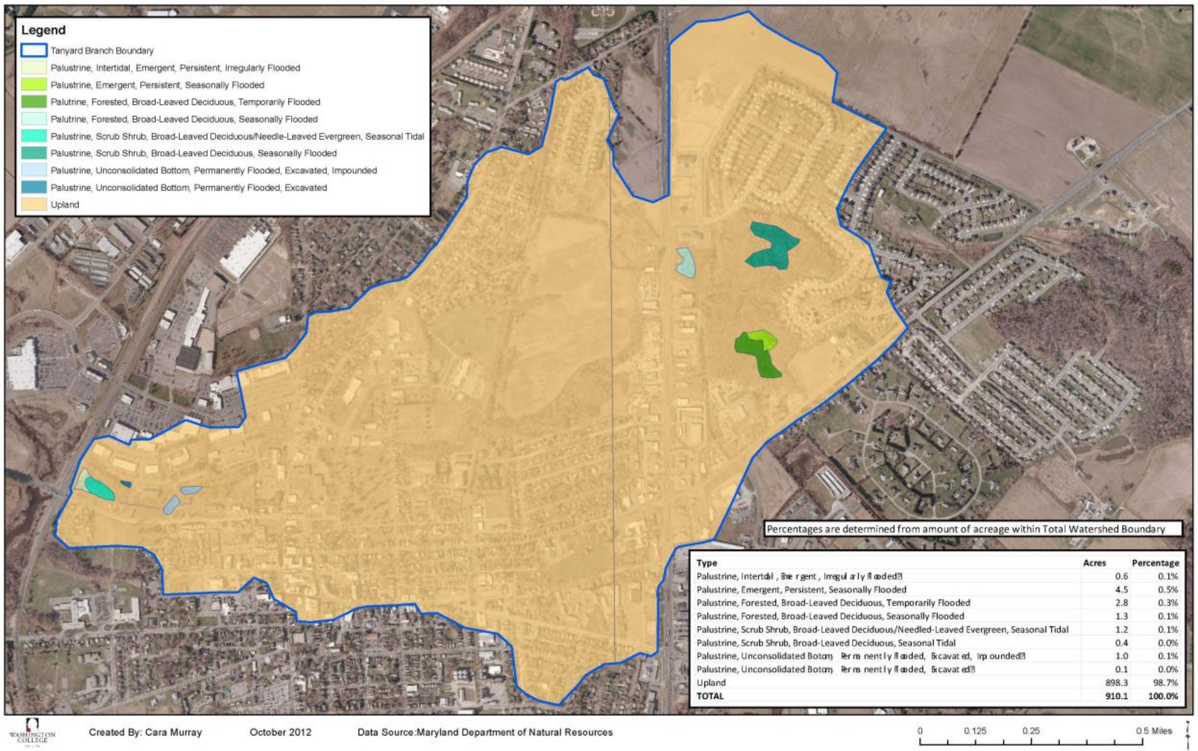
Tanyard Watershed Residential Grass Evaluation (Figure 12)



Type	Acres	Percentage
Unknown	663.1	73%
High Nitrogen	112.5	12%
Average Nitrogen	110.9	12%
Low Nitrogen	24.3	3%
TOTAL	**910.8**	**100%**

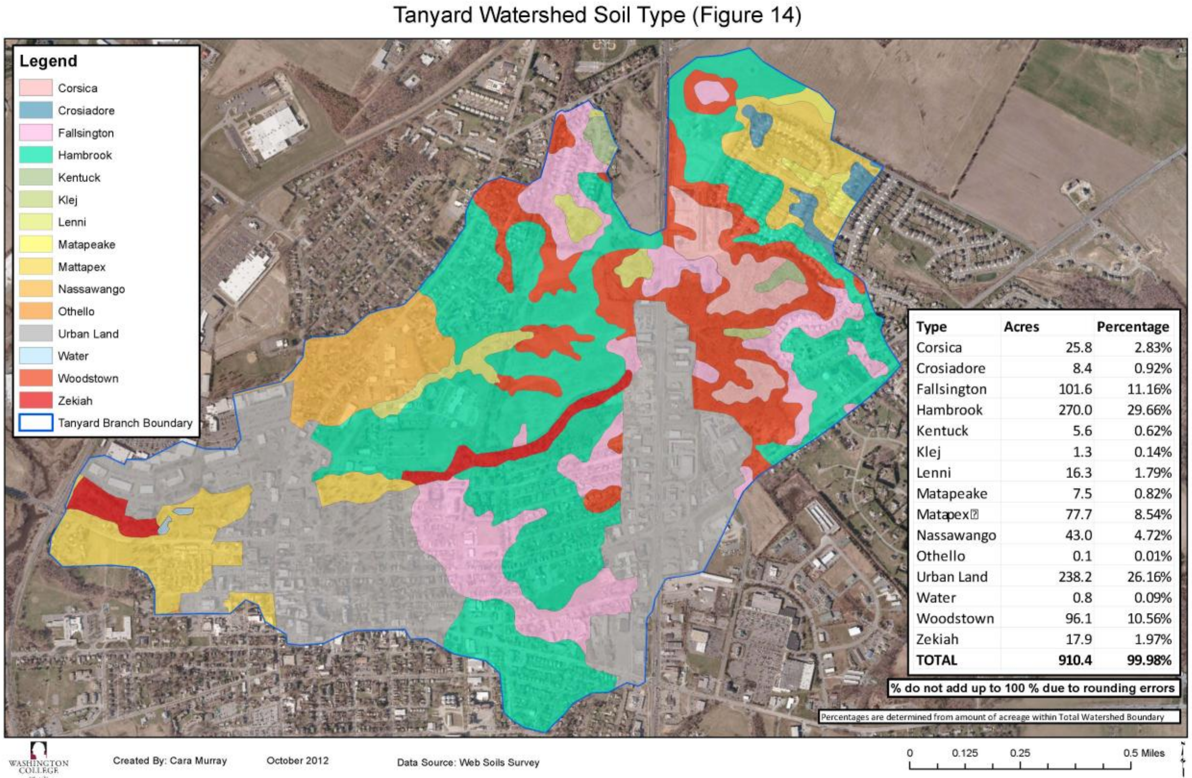
Figure 12: Residential Grass Evaluation
Using Talbot County parcels as a base all residential parcels were identified. The each parcel was visually examined and rated by comparing the brightness of the grass by using leaf-off aerial imagery and also by using WorldView II multispectral imagery. When the area was attributed it received a “Green Factor” score which was a number from 0-3 that categorized the brightness of the grass from dull (0) to very bright (3). The data was then clipped to the Tanyard Branch Watershed Boundary; and the coverage of the green grass was analyzed to determine acreage and percentage of watershed covered.

Tanyard Watershed Wetlands (Figure 13)



Type	Acres	Percentage
Palustrine, Intertdal , Ehe r gent , Irregul ar ly fl ooded	0.6	0.1%
Palustrine, Emergent, Persistent, Seasonally Flooded	4.5	0.5%
Palustrine, Forested, Broad-Leaved Deciduous, Temporarily Flooded	2.8	0.3%
Palustrine, Forested, Broad-Leaved Deciduous, Seasonally Flooded	1.3	0.1%
Palustrine, Scrub Shrub, Broad-Leaved Deciduous/Needled-Leaved Evergreen, Seasonal Tidal	1.2	0.1%
Palustrine, Scrub Shrub, Broad-Leaved Deciduous, Seasonal Tidal	0.4	0.0%
Palustrine, Unconsolidated Botom Per ma nent ly fl ooded, Excavat ed, Im pounded	1.0	0.1%
Palustrine, Unconsolidated Botom Per ma nent ly fl ooded, Excavat ed	0.1	0.0%
Upland	898.3	98.7%
TOTAL	**910.1**	**100.0%**

Figure 13: Wetlands
This data was received from the Maryland Department of Natural Resources and was clipped to the watershed boundary.



Type	Acres	Percentage
Corsica	25.8	2.83%
Crosiadore	8.4	0.92%
Fallsington	101.6	11.16%
Hambrook	270.0	29.66%
Kentuck	5.6	0.62%
Klej	1.3	0.14%
Lenni	16.3	1.79%
Matapeake	7.5	0.82%
Matapex	77.7	8.54%
Nassawango	43.0	4.72%
Othello	0.1	0.01%
Urban Land	238.2	26.16%
Water	0.8	0.09%
Woodstown	96.1	10.56%
Zekiah	17.9	1.97%
TOTAL	**910.4**	**99.98%**

Figure 14: Soil Type
Using the boundary of the watershed as an Area of Interest (AOI), the staff clipped the NRCS soils data from the NRCS web soil survey site. The various types and acreages of various soils were then determined.

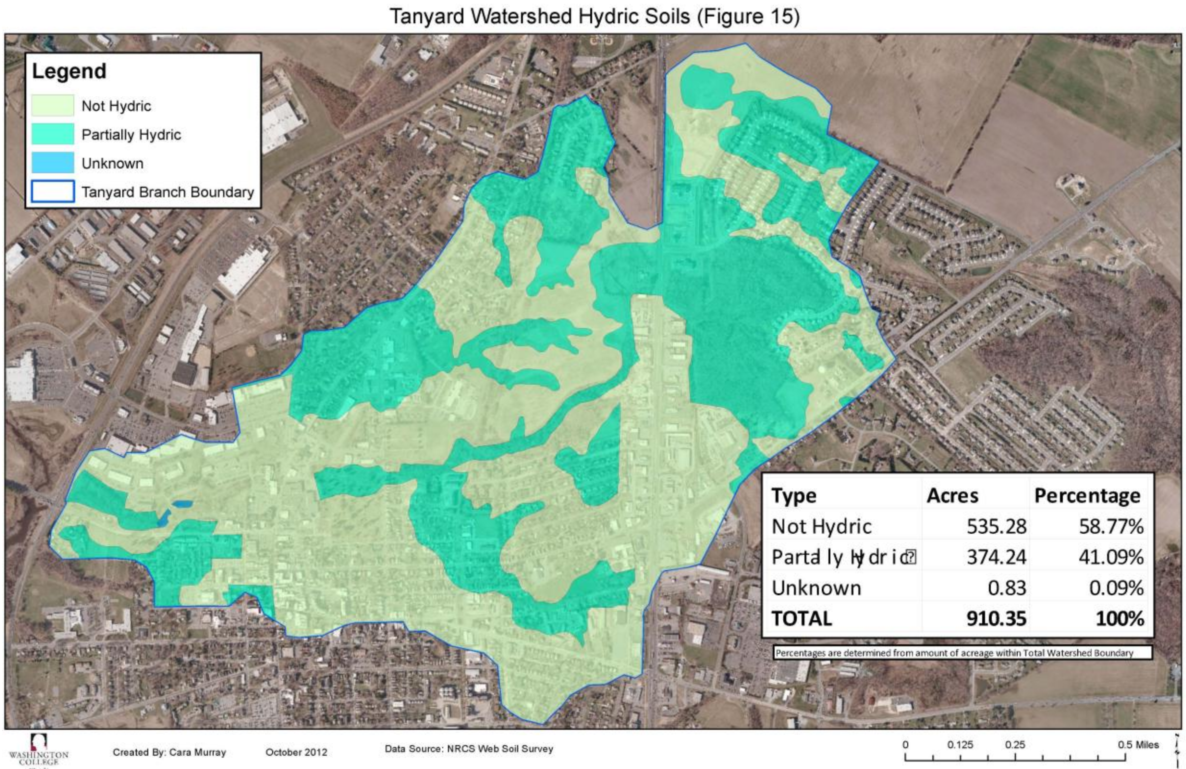


Figure 15: Hydric Soils
Using the boundary of the watershed as an Area of Interest (AOI), the staff clipped the NRCS soils data from the NRCS web soil survey site. This map shows whether the soils are hydric, partially hydric, or not hydric.

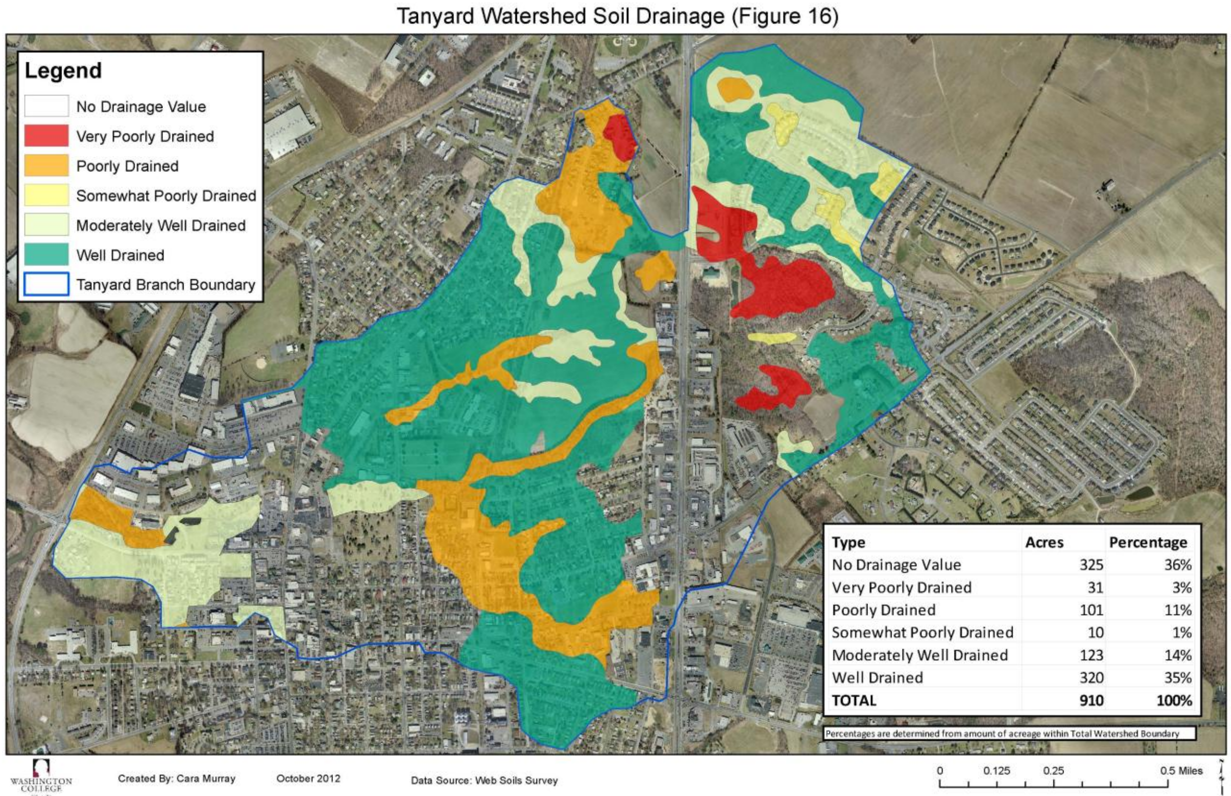


Figure 16: Soil Drainage
Using the boundary of the watershed as an Area of Interest (AOI), the staff clipped the NRCS soils data from the NRCS web soil survey site.

Tanyard Watershed Ponding Frequency (Figure 17)

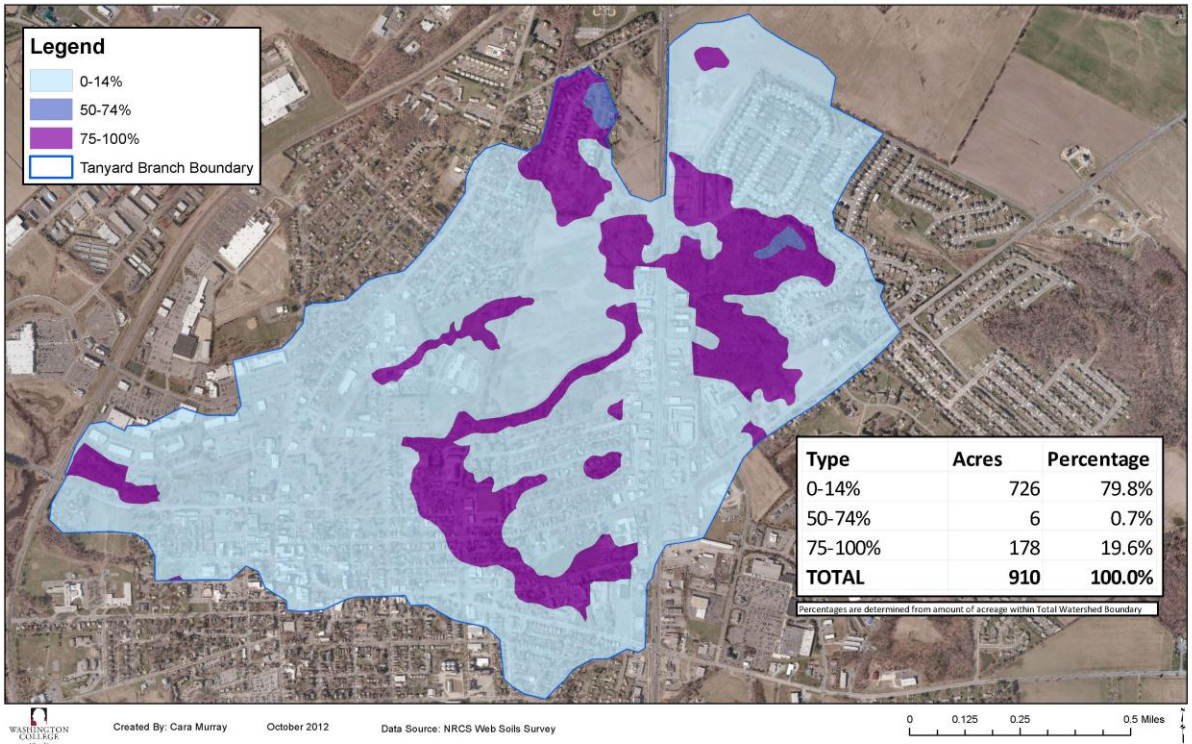
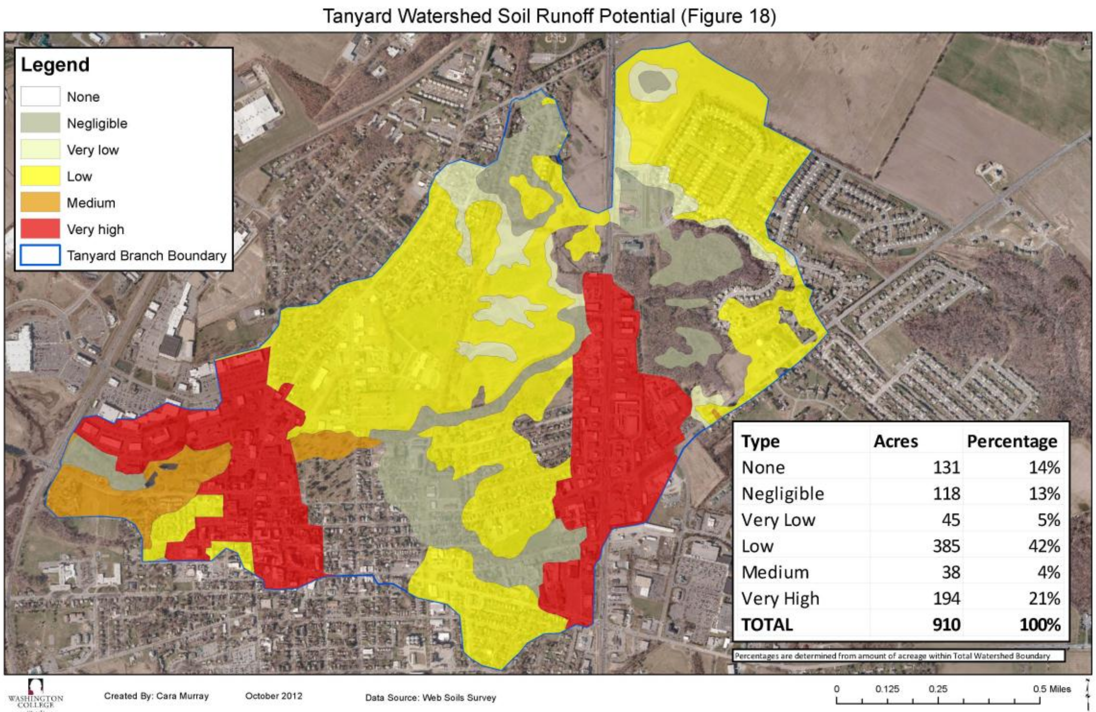


Figure 17: Ponding Frequency
Using the boundary of the watershed as an Area of Interest (AOI), the staff clipped the NRCS soils data from the NRCS web soil survey site. This map shows the ponding frequency.



Type	Acres	Percentage
None	131	14%
Negligible	118	13%
Very Low	45	5%
Low	385	42%
Medium	38	4%
Very High	194	21%
TOTAL	**910**	**100%**

Figure 18: Runoff Potential
Using the boundary of the watershed as an Area of Interest (AOI), the staff clipped the NRCS soils data from the NRCS web soil survey site. This map shows the soil runoff potential.

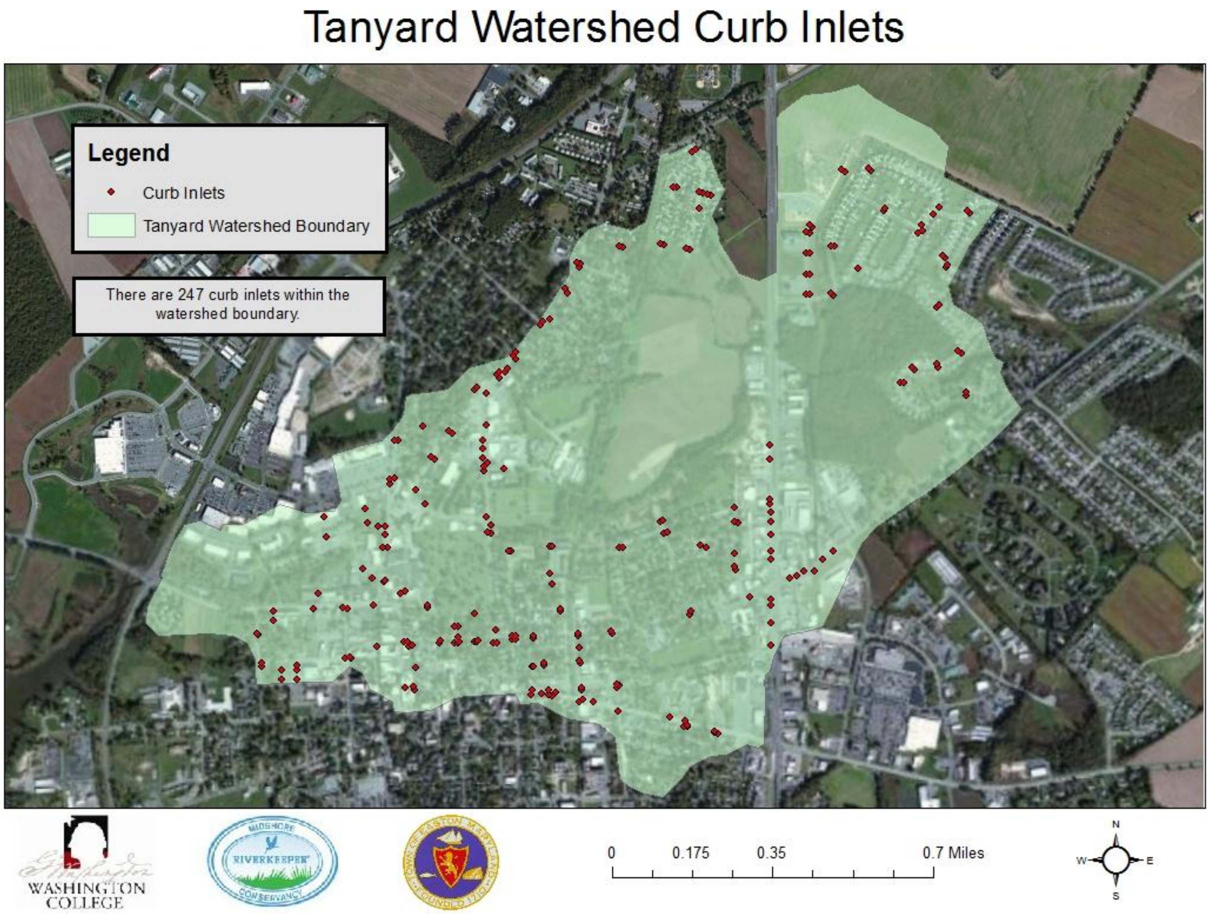


Figure 19: Curb Inlets
Using data collected from a related project with the Town of Easton, a map was generated to show all stormwater curb inlets within the watershed boundary.

10.2 Bioretention

In this section, we briefly introduce the major critical processes that occur with bioretention facilities:

Interception-The collection or capture of rainfall or runoff by plants or soils. Plant stems, leaves, and mulch within the bioretention facility intercept rainfall and runoff, which then pools in the center of the facility.

Infiltration-The downward migration of runoff through the planting soil and into the surrounding *in-situ* soils. Infiltration can be a major process in bioretention facilities. Infiltration will occur in bioretention facilities, with or without underdrain systems.

Settling-As the runoff slows and ponds within the bioretention area, particles and suspended solids will settle out. This process occurs on the surface of the bioretention facility, providing pretreatment before entering the filter medium.

Evaporation-Thin films of water are changed to water vapor by the energy of sunlight. Bioretention facilities have a very shallow ponding area--only 6-12 inches deep--to facilitate evaporation.

Filtration-Particles are filtered from runoff as it moves through mulch and soil. In bioretention facilities, filtration removes most particulates from runoff.

Absorption-Water is absorbed into the spaces between soil particles and then is taken up by plant root hairs and their associated fungi.

Transpiration-Water vapor that is lost through leaves and other plant parts. More than 90 percent of the water taken into a plant's roots returns to the air as water vapor.

Evapotranspiration-Water lost through the evaporation of wet surfaces plus water lost through transpiration. The bioretention facility design maximizes the potential for this process to occur. This plant/soil/runoff relationship is one of the processes that set bioretention apart from conventional BMP's.

Assimilation-Plants taking in nutrients and using them for growth and other biological processes. Designers can select plants used in bioretention facilities for their ability to assimilate certain kinds of pollutants.

Adsorption-The ionic attraction holding a liquid, gaseous, or dissolved substance to a solid's surface. Humus, which can be found in bioretention facilities with the breakdown of mulch and plant matter, adsorbs metals and nitrates. Leaf mulch or compost is used as part of bioretention planting soils to provide humus. Soils with significant clay content are not used for bioretention facilities, however, because clay soils impede infiltration and might actually promote clogging.

Nitrification-Bacteria oxidize ammonia and ammonium ions to form nitrate (NO_3) a highly soluble form of nitrogen that is readily used by plants.

Denitrification-When soil oxygen is low, temperatures are high, and organic matter is plentiful, microorganisms reduce nitrate (NO_3) to volatile forms such as nitrous oxide (N_2O) and nitrogen gas (N_2), which return to the atmosphere. The designer can use various techniques to maximize denitrification. One way to do this is to incorporate an anaerobic zone in the bioretention facility by raising the underdrain pipe invert above the base of the bioretention facility. Generally, mature soils with good structure denitrify more quickly.

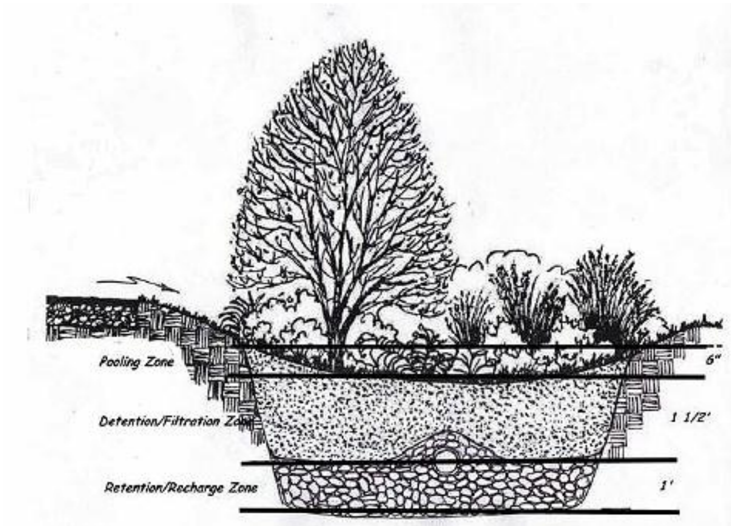
Volatilization-Converting a substance to a more volatile vapor form. Denitrification is an example of volatilization as well as the transformation of complex hydrocarbons to CO_2.

Thermal Attenuation-Thermal attenuation is achieved by filtering runoff through the protected soil medium of a bioretention facility. One study showing thermal attenuation attributable to bioretention found that the temperature of input runoff was reduced from 91.4 degrees to 71.6 degrees (Minami and Davis 1999). Bioretention facilities have an advantage over shallow marshes or ponds with respect to thermal attenuation. Thermal pollution of streams from urban runoff increases the likelihood of fish kills and degraded stream habitat.

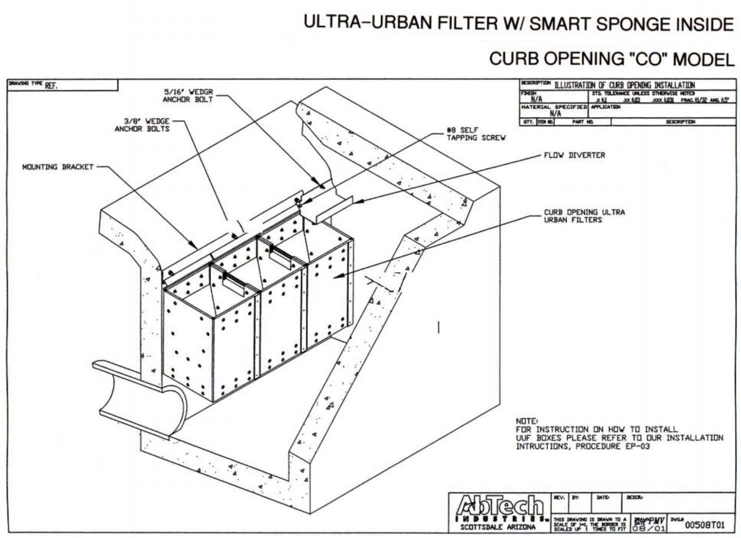
Degradation-The breaking down of chemical compounds by microorganisms in the soil medium.

Decomposition-The breakdown of organic compounds by the soil fauna and fungi.

10.3 Photos of All Recommended Pollution Reduction Practices



This is a schematic of a typical bioretention design.



This is a schematic of ultra -urban filters installed inside a curb-inlet structure. The vast majority of pollution is carried in the first ½" of runoff. Heavy flows will bypass filters.

This is a photo of a typical bioswale with curb inlet from road.

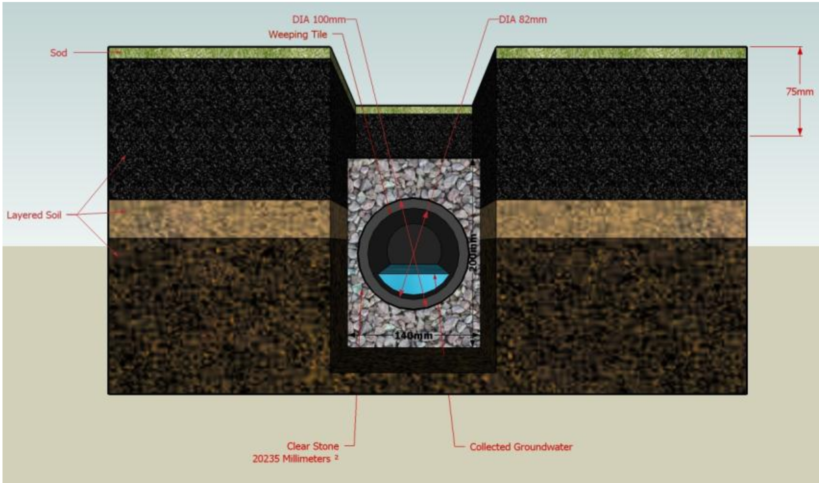


Photo of a typical French drain.

Floating wetlands in Baltimore Harbor.

Photo of a rain barrel with an overflow hose, spigot and soaker hose for watering the lawn.

10.4 Retrofit Location Property Owners

Retrofit Code	Owner Name Line 1	Owner Name Line 2	Owner Address Line 1	Owner Address Line 2	City	State	Zip	Account ID
TB1-BF1	Tred Avon LLC	C/O Greenberg Commercial	10096 Red Run Blvd, Suite 100		Owings Mills	MD	21117-4827	2101009524
TB1-BF2	Tred Avon LLC	C/O Greenberg Commercial	10096 Red Run Blvd, Suite 100		Owings Mills	MD	21117-4827	2101009524
TB1-BF3	Mears Properties LLC		600 Mercantile Bank & Trust	2 Hopkins Plaza	Baltimore	MD	21201	2101083872
TB1-BF4	Mears Properties LLC		600 Mercantile Bank & Trust	2 Hopkins Plaza	Baltimore	MD	21201	2101083872
TB1-BR1	Eastern Shore Retirement	Associates Limited Partmership	C/O David Hill	501 Idlewild Ave	Easton	MD	21601	2101085255
TB1-BR2	Eastern Shore Retirement	Associates Limited Partmership	C/O David Hill	501 Idlewild Ave	Easton	MD	21601-4049	2101085212
TB2-BR1	Easton Shopping Center LLC		13404 Day Valley Court		Centreville	VA	20120-6422	2101063871
TB2-BS1	Easton Shopping Center LLC		13494 Day Valley Court		Centreville	VA	20120-6422	2101063871
TB2-BS2	Easton Shopping Center LLC		13494 Day Valley Court		Centreville	VA	20120-6422	2101063871
TB3-BR1	Marlboro Plaza Business Trust		P.O. Box 1765		Easton	MD	21601-8935	2101064193
TB3-BS1	Mears Properties LLC	C/O Walter R. Stone	7 St Paul Street, Suite 600		Baltimore	MD	21202-1612	2101064169
TB3-BS2	Marlboro Plaza Business Trust		P.O. Box 1765		Easton	MD	21601-8935	2101064193
TB3-FD1	Marlboro Plaza Business Trust		P.O. Box 1765		Easton	MD	21601-8935	2101064193
TB3-FD2	Marlboro Plaza Business Trust		P.O. Box 1765		Easton	MD	21601-8935	2101064193
TB4-BR1	C.S. Tarbutton, Inc.		6 Mt. Pleasant Ave		Easton	MD	21601-3715	2101005820
TB4-BR2	Town of Easton		P.O. Box 520		Easton	MD	21601	2101027220
TB4-BR3	Town of Easton		P.O. Box 520		Easton	MD	21601	2101027220
TB5-FW1	Bay Street Ponds, LLC	C/O Grayce B. Kerr Fund, Inc.	40 S. Harrison St		Easton	MD	21601-3019	2101068091
TB6-FW1	Bay Street Ponds, LLC	C/O Grayce B. Kerr Fund, Inc.	40 S. Harrison St		Easton	MD	21601-3019	2101068105
TB7-BR1	Talbot County, Maryland		11 N. Washington St., Suite 9		Easton	MD	21601-3195	2101014587
TB7-BS1	Talbot County, Maryland		11 N. Washington St., Suite 9		Easton	MD	21601-3195	2101014587
TB7-BS2	Talbot County,		11 N. Washington St., Suite 9		Easton	MD	21601-3195	2101014587

	Maryland							
TB7-RG1	Talbot County, Maryland		11 N. Washington St., Suite 9		Easton	MD	21601-3195	2101014587
TB7-RG2	Talbot County, Maryland		11 N. Washington St., Suite 9		Easton	MD	21601-3195	2101014587
TB7-RG3	Talbot County, Maryland		11 N. Washington St., Suite 9		Easton	MD	21601-3195	2101014587
TB8-WRA1	Town of Easton		P.O. Box 520		Easton	MD	21601	2101064673
TB8-WRA2	Town of Easton		P.O. Box 520		Easton	MD	21601	2101064673
TB8-WRB	Town of Easton		P.O. Box 520		Easton	MD	21601	2101064673
TB8-WRC	Easton Commerce Center	Limited Partnership	C/O Alvin Lapidus	1726 Reisterstown Rd Suite 212	Baltimore	MD	21208-2974	2101063790
TB8-WRD	Easton Commerce Center	Limited Partnership	C/O Alvin Lapidus	1726 Reisterstown Rd Suite 212	Baltimore	MD	21208-2974	2101063790
TB9-BR1	Town of Easton		P.O. Box 520		Easton	MD	21601	2101027077
TB9-BS1	Richland Memorial Park				Easton	MD	21601	2101026887
TB9-BS2	Town of Easton		P.O. Box 520		Easton	MD	21601	2101027077
TB10-BRA	Town of Easton		P.O. Box 520		Easton	MD	21601	2101027093
TB10-BRB	Town of Easton		P.O. Box 520		Easton	MD	21601	2101027093
TB10-BRC	Town of Easton		P.O. Box 520		Easton	MD	21601	2101027123
TB11-BR1	Bay Street Ponds, LLC	C/O Grayce B. Kerr Fund, Inc.	40 S. Harrison St		Easton	MD	21601-3019	2101025775
TB11-BR2	Talbot County, Maryland		11 N. Washington St., Suite 9		Easton	MD	21601-3195	2101063189
TB11-BR3	Talbot County, Maryland		11 N. Washington St., Suite 9		Easton	MD	21601-3195	2101063189
TB12-BR1	Town of Easton		P.O. Box 520		Easton	MD	21601	2101027050
TB14-FW	Fleming and Kagan Trustees		8448 Ocean Gateway	Suite 1	Easton	MD	21601	2101007122
TB15-SHA-BR1								
TB15-SHA-BR2								
TB15-SHA-BR3								
TB15-SHA-BR4								

TB15-SHA-BR5								
TB15-SHA-BR6								
TB15-SHA-BR7								
TB15-SHA-BR8								
TB15-SHA-BR9								
TB15-SHA-BR10								
TB15-SHA-BR11								
TB15-SHA-BR12								
TB15-SHA-BR13								
TB15-SHA-BR14								
TB16-BR1	Durham, Robert W., Trustee	C/O Tina Rogers, Controller	Hardees/OTAC, Inc.	528 College Pkway, Suite 1	Annapolis	MD	21401	2101047639
TB16-FD1	Durham, Robert W., Trustee	C/O Tina Rogers, Controller	Hardees/OTAC, Inc.	528 College Pkway, Suite 1	Annapolis	MD	21401	2101047639
TB16-FD2	Durham, Robert W., Trustee	C/O Tina Rogers, Controller	Hardees/OTAC, Inc.	528 College Pkway, Suite 1	Annapolis	MD	21401	2101047639
TB16-BR2	Durham, Robert W., Trustee	C/O Tina Rogers, Controller	Hardees/OTAC, Inc.	528 College Pkway, Suite 1	Annapolis	MD	21401	2101047639
TB16-BR3	Durham, Robert W., Trustee	C/O Tina Rogers, Controller	Hardees/OTAC, Inc.	528 College Pkway, Suite 1	Annapolis	MD	21401	2101047639
TB17-BR/WR	Whalen Properties	Limited Partnership	2 E Rolling Crossroads	Suite 203	Catonsville	MD	21228-6211	2101006851
TB17-BR/WR	Wet Dog Property Acquisition LLC		29328 Matthewstown Rd		Easton	MD	21601-7112	2101004026
TB17-BR2	HJR-Benson Venture LLC	C/O Carroll Independent	2700 Loch Raven Rd		Baltimore	MD	21218-4729	2101054147
TB18-BR1	Hardisty, Mark E.	Hardisty, Joseph E.	24441 Asbury Dr		Denton	MD	21629-2224	2101023403
TB19-BR1	Barnard Properties Partnership		P.O. Box 179		Milford	DE	19963-0179	2101050354
TB19-BR2	Barnard Properties Partnership		P.O. Box 179		Milford	DE	19963-0179	2101050354

TB19-FD1	Ambell, James E.		7102 Wells Pkway		University Park	MD	20782-1041	2101056034
TB19-FD1	Barnard Properties Partnership		P.O. Box 179		Milford	DE	19963-0179	2101050354
TB19-FD2	Ambell, James E.		7102 Wells Pkway		University Park	MD	20782-1041	2101056034
TB19-FD2	Barnard Properties Partnership		P.O. Box 179		Milford	DE	19963-0179	2101050354
TB20-SHA-BF1								
TB20-SHA-BF2								
TB20-SHA-BF3								
TB20-SHA-BF4								
TB20-SHA-BF5								
TB20-SHA-BF6								
TB20-SHA-BF7								
TB20-SHA-BF8								
TB20-SHA-BF9								
TB20-SHA-BF10								
TB20-SHA-BF11								
TB20-SHA-BF12								
TB20-SHA-BF13								
TB21-BS1	Nielsen, Marvin E., Jr.		27938 Oaklands Circle		Easton	MD	21601-8262	2101063960

10.5 CES Methodologies for Water Quality Sampling

Temperature, Conductivity, Dissolved Oxygen, and pH:

Water quality observations for temperature (T), conductivity (C), dissolved oxygen (DO), and pH were made using either a YSI 600 XLM sonde fitted with a hand-held 650MDS (data display and logger) or a YSI Professional Plus handheld multiparameter meter. Each unit was calibrated and recorded using certified standards prior use in the field. Data were recorded on individual site field sheets. General weather patterns and other observations, if necessary, were also noted. Samples were collected and analyzed in the following manner:

Enterococci:

After meter readings were obtained and recorded, a sample for enterococci (pathogen indicator) was collected just upstream from the site where meter readings were taken by inverting a sterile sample bottle with gloved hands into the water and turning the bottle upstream to fill beyond the 100 ml mark. The entrococci sample was then immediately capped and placed in a plastic bag on ice for transport back to the lab. Enterococci samples were processed within four (4) hours of collection. Enterococci sample analyses were conducted after 24 hour incubation at 41.5^{o}C following the procedure outlined by Enterolert^{TM} (IDEXX Laboratories). Values for enterococci are reported as most-probable-number (MPN) per 100 mls.

Nutrients:

After collection of the enterococci sample, water from the Tanyard Branch was drawn through a pre-cleaned 60 ml plastic syringe (BD^{TM}) fitted with a luer-loc check valve and Swinnex^{TM} filter holder. Whatmann GF/F (25 mm) glass fiber filters were used for filtration. Pre-cleaned nutrient bottles were rinsed three (3) times with filtered Tanyard Branch water before filling and stored on ice. Nutrient analysis was conducted for nitrate (NO_3), ammonia (NH_3), ortho-phosphate (o-PO_4) within 12 hours of sample collection following the HACH$^{(R)}$ methods of 10206, 10205, and 10209, respectively. Total nitrogen (TN) and total phosphorus (TP) were analyzed within 48 hours of collection following the HACH$^{(R)}$ methods of 10071 and 10210, respectively. All nutrient concentrations were determined using a HACH$^{(R)}$ DR2800 spectrophotometer.

Total Suspended Solids:

Following collection and filtration of nutrient samples, a bulk water samples were collected and brought back to the lab for processing total suspended solids (TSS) samples.

Briefly, aliquots of TSS samples were obtained from the 2L polycarbonate bottles filled in the field. Filters (47 mm, 0.4 µm Poretics® polycarbonate membranes) for TSS were pre-weighed by placing filters in a dessicator for a minimum of three (3) days prior to weighing on the Cahn ultrabalance. Tared filters were then stored in disposable Falcon® Petri dishes (Fisher Cat. # 08-757-105) with their tared weight recorded on the Petri dish cap with a permanent marker.]

A filtration apparatus (Nalgene® polysulfone filtration apparatus: Fisher Cat. # 09-740-23D) was used to process the TSS samples. A Teflon fitting is connected, for vacuum, to one of the ports on the top of the filtrate receiver. Forceps are used to remove a tared polycarbonate filter from Petri dish and placed onto the analytical plate (the two-piece white/off-white support bed) of the filtration apparatus. The Petri dish with the tared filter weight recorded on the cap is saved for later storage of processed sample. The top portion of the filtration apparatus is placed on and screw down finger tight. A reasonable" amount of sample is filtered for TSS measurement. After sample has been completely filtered, the vacuum is removed and the filtrate decanted through one of the ports on the filtration receiver into an appropriate graduate cylinder to determine the amount of filtrate processed. This volume is recorded (V_f). After obtaining the filtrate volume, the vacuum is re-applied and the filter is rinsed with 10 – 20 ml of purified laboratory water (QHOH) using a squirt bottle and rinsing all of the filter and sides of the apparatus, to ensure complete particle collection and to remove residual saltwater (if applicable) from filter. Residual saltwater trapped in the filter pore spaces may add a substantial amount of mass if allowed to dry with captured particulates. Following the QHOH rinse, the top portion of apparatus is removed away from receiver; the filter is removed by using forceps and returned to its original Petri dish. The processed filter with particulate matter (TSS sample) is kept open in a dessicator, and allowed to dry for a minimum of three (3) days prior to re-weighing. After filters have been desiccated, the filters are weighed again on the Cahn ultrabalance, recording to the nearest 1/1000th mg (M_s).

Blanks are processed in the same manner, using 50 mLs of QHOH. Sometimes QHOH may be contaminated with particles and a better measure of “blanks” are obtained from re-weighing “control” filters-those that were not subjected to any filtration processing. As a control of relative humidity, three (3) pre-weighed filters are reserved for re-weighing at the time of sample weighing. On occasion, these filters will be consistently higher or lower (~0.01 mg) than when originally weighed. Use the mean value (M_b) to correct sample weights for effects of relative humidity. TSS values are calculated as follows:

$[(M_s – M_t) – M_b]/(V_f)$

where:
M_s is the mass of filter *plus* sample in mg
M_t is the mass of filter *(tared wt.)* in mg
M_b is mean blank value in mg
V_f is the filtrate volume (in liters)

Chlorophyll a analysis

For chlorophyll a analysis, the filter used to process the nutrient samples above was removed and placed in a extraction vial. Under a low-light regime, 10 mL of 90% acetone (10% DI HOH[i]) v/v is added to the test tube/filter and vigorously shaken. An aliquot of the 90% acetone is saved for a reagent blank. Sample procedural blanks where also performed by filtering a representative “sample” volume (50-100 mL) using deionized water, through two filters loaded in the filtration apparatus. Procedural blanks are performed on the most downstream filter. Test tubes with the extracting sample were stored in the dark at 0^oC (in freezer) for 12 – 24 hrs prior to fluorometric analysis. A Turner Designs Model 10 Series Fluorometer was used for completing the chlorophyll analyses. Briefly, samples were allowed to equilibrate to near room temperature prior to reading the relative fluorescence intensity. An initial read was conducted and recorded as $\mathbf{R_b}$**.** After the addition of 2 drops of 5% v/v HCl to the cuvette a 2nd reading after 30 second equilibration was obtained and recorded as $\mathbf{R_a}$. The chlorophyll a concentrations were computed by converting the measured fluorescence relative intensities to chlorophyll and phaeo-pigments concentrations using the following equations:

Chl *a* (ug L^{-1}) = $10 \times [(F_d \times (t/t\text{-}1)] \times [((R_{b\ samp}/Scale_{b\ samp}) - (R_{a\ samp}/Scale_{a\ samp}))/\text{Samp. Vol } (mL))]$

Phaeo-pigment (ug L^{-1}) = $10 \times [(F_d \times (t/t\text{-}1)] \times [((R_{a\ samp}/Scale_{a\ samp}) - (R_b/Scale_{b\ samp}))/\text{Samp. Vol } (mL))]$
13)
where:
$t = (\text{mean } R_{b\ std}/ \text{ mean } Scale_{b\ std}) / (\text{mean } R_{a\ std}/ \text{ mean } Scale_{a\ std})$
F_d (door factor) = Fluorescence Standard Conc. (ug L^{-1}) / (mean $R_{b\ std}$/ mean $Scale_{b\ std}$)

All samples were standardized using a commercially available chlorophyll a standard (Sigma-Aldrich®). The fluorescence standard is made by quantitative dilution (typically 1/50) of the spectrophotometric standard. The spectrophotometric standard is determined by reading absorbances at 630, 647, 664, and 750 nm. The concentration of the spectrophotometric standard is calculated by:

Chl *a* (mg L^{-1}) = $11.45 (Abs_{664} - Abs_{750}) – 1.54(Abs_{647} - Abs_{750}) - 0.008(Abs_{630} - Abs_{750})$

Flow Monitoring:

Flow monitoring was also conducted at all Tanyard Branch sites. Briefly, a section of the stream was selected that had fairly consistent geometry between two fixed points. A representative cross-section bathymetry was measured at selected points along the cross-stream transect and used to calculate the cross-section area of the stream. The stream velocity was then determined as a function of the time it took for a surface drogue (orange peel) to traverse between the two pre-measured points along the stream's axis. The drogue velocity was repeated four (4) additional times and the average stream velocity was used along with the stream cross section area to calculate the volume of water flowing at each station. These flow estimates were used with analyte concentrations (TN, TP, and TSS) to estimate loadings from the Tanyard Branch.

10.6 Water Quality Data and Load Reduction Calculation

10.6.1 Dry weather water quality data at site TB5

Date	Time	Temp (F°)	DO SAT	DO (mg/L)	PH	Flow (ft^3/s)	TN (mg/l)	TP (mg/l)	TN/TP	Comments
5/15/2012	10:40 AM	67.6	88	7.2	8.0					
5/16/2012	10:58 AM	69.4	98	8.8	8.1	3.28	0.80	0.88	0.91	
5/29/2012	11:15 AM	74.8	117	9.8	8.6	1.16	1.20	0.58	2.07	
6/5/2012	10:38 AM	71.2	85	6.6	7.7					significant amounts of algae downstream of sampling site
6/28/2012	1:06 PM	78.8	67	5.5	8.2					heavy algae in stream, downstream of site
7/10/2012	10:37 AM	83.1	61	4.9	8.1					mats of algae in stream, downstream of site
7/16/2012	10:08 AM	77.5	97	8.2	8.2	0.54	1.10	0.52	2.12	
7/20/2012	11:13 AM	79.5	99	7.9	8.0	0.63	0.80	0.41	1.95	
10/11/2012	12:43 PM	64.9	119	11.2	7.3					Temp increase from upstream due to stream burial
10/25/2012	2:30 PM	67.6	92	8.5	8.1	0.35	1.10	0.20	5.50	
	Average	73.4	92.3	7.9	8.0	1.2	1.0	0.5	1.93	

10.6.2 Dry Weather Sampling by Washington College

16 May 2012

Sample	Time	T (°C)	C (uS)	S (o/oo)	DO (mg L^{-1})	pH
TB2	9:15	21.2	0.124	0.07	5.35	6.1
TB2B	9:53	21.4	0.162	0.08	5.68	6.5
TB4	10:16	20.8	0.199	0.09	7.81	6.8
TB5	10:58	20.8	0.329	0.16	8.78	8.07
TB5R	10:58					8.02
TB8	11:06	22.5	0.307	0.15	8.48	7.79

Sample	Entero (MPN 100 ml^{-1})	TN (mg N L^{-1})	NH_3 (mg N L^{-1})	NO_3 (mg N L^{-1})	TP (mg N L^{-1})	o-PO_4 (mg N L^{-1})	TSS (mg L^{-1})	Chl a (µg L^{-1})
TB2	1733	1.4	0.05	0.59	0.87	0.66	84	1.7
TB2B	>2420	5.9	2.6	3.08	0.62	0.04	NA	0.9
TB4	1986	0.1	0.07	0.22	0.72	0.27	20	2.0
TB5	>2420	0.8	0.08	0.35	0.88	0.58	18	1.7
TB5R	1414	0.5	0.07	0.43	0.87	0.72		1.3
TB8	1100	0.8	0.17	0.31	1.15	0.59	50	2.2

29 May 2012

Sample	Time	T (°C)	C (uS)	S (o/oo)	DO (mg L^{-1})	pH
TB2b	10:20	24.8	0.291	0.14	5.69	6.78
TB4	10:55	23.62	0.343	0.16	5.89	
TB5	11:15	23.76	0.286	0.14	9.8	8.62
TB8	11:55	29.43	7.173	3.88	15.21	
TB8R	11:55	29.74	4.524	2.89	15.21	

Sample	Entero (MPN 100 ml^{-1})	TN (mg N L^{-1})	NH_3 (mg N L^{-1})	NO_3 (mg N L^{-1})	TP (mg N L^{-1})	o-PO_4 (mg N L^{-1})	TSS (mg L^{-1})	Chl a (µg L^{-1})
TB2b	151	1.6	0.43	(4.2)	0.06	0.1	23	0.8
TB4	479	1.2	0.07	1.8	0.48	0.21	5	2.6
TB5	1986	1.2	0.05	1.9	0.58	0.29	10	2.1
TB8	74	0.6	0	0	0.37	0.24	5	4.7
TB8R	120	0.2	0	0	0.09	0.23		

16 July 2012

Sample	Time	T (°C)	C (uS)	S (o/oo)	DO (mg L^{-1})	pH
TB2b	11:07	28.67	0.422	0.11	4.83	7.59
TB4	11:53	27.3	0.284	0.14	5.46	7.61
TB5	10:08	25.29	0.416	0.2	8.15	8.22
TB8	10:45	30.12	1.289	0.63	5.48	7.7

Sample	Entero (MPN 100 ml^{-1})	TN (mg N L^{-1})	NH_3 (mg N L^{-1})	NO_3 (mg N L^{-1})	TP (mg N L^{-1})	o-PO_4 (mg N L^{-1})	TSS (mg L^{-1})	Chl a (µg L^{-1})
TB2b	>2420	0.7	0.19	0.23	0.35	0.41	370	3.1
TB4	1300	1.5	0.06	0.27	0.78	0.43	12.5	1.8
TB5	261	1.1	0.04	0.63	0.52	0.42	2.0	2.2
TB8	187	1.1	0.19	0.18	0.77	0.63	8.3	4.3

20 July 2012

Sample	Time	T (°C)	C (uS)	S (o/oo)	DO (mg L^{-1})	pH
TB2b	12:05	26.69	0.297	0.14	5.80	6.01
TB4	11:30	26.5	0.119	0.05	5.66	7.37
TB5	11:13	26.39	0.352	0.17	7.87	7.98
TB8	11:26	28.2	0.734	0.36	5.32	7.60

Sample	Entero (MPN 100 ml^{-1})	TN (mg N L^{-1})	NH_3 (mg N L^{-1})	NO_3 (mg N L^{-1})	TP (mg N L^{-1})	o-PO_4 (mg N L^{-1})	TSS (mg L^{-1})	Chl a (µg L^{-1})
TB2b	5172	1.9	0.05	0.23	0.28	0.09	8.9	0.3
TB4	5012	0.8	0.00	0.38	0.45	0.22	5	1.0
TB5	2489	0.8	0.02	0.64	0.41	0.31	3.8	0.8
TB8	2851	0.6	0.05	0.49	0.00	0.20	10	1.1

25 October 2012

Sample	Time	T °C	C uS	S o/oo	DO (mg L^{-1})	pH
TB2b	-------------------------no flow --------------------------					
TB4	14:02	18.2	365	0.18	6.56	7.5
TB5	14:30	19.8	424	0.2	8.47	8.13
TB5R						
TB8	15:07	20.1	18234	10.8	6.39	7.8

Sample	Time	Entero (MPN 100 ml^{-1})	TN (mg N L^{-1})	NH_3 (mg N L^{-1})	NO_3 (mg N L^{-1})	TP (mg N L^{-1})	o-PO_4 (mg N L^{-1})	TSS (mg L^{-1})	Chl *a* (µg L^{-1})
TB2b	---no flow --								
TB4	14:02	309		0.01	0.4		0.18		NC
TB5	14:30	135	1.1	0.03	0.84	0.2	0.13	1.5	NC
TB5R		98							
TB8	15:07	1421		0.03	0.31		0.12		NC

T= Temp., C=Specific Conductivity, S=Salinity, DO=Dissolved Oxygen, Entero= Enterococci, TN=Total Nitrogen, TP, Total Phosphoruous, TSS=Total Suspended Solids, Chl *a* = Chlorophyll a ; "R" represents replicate sample/analysis. "( )" indicates inconsistent result possibly due to contamination.

10.6.3 Dry Weather Sampling by Midshore Riverkeeper Conservancy

5 May 201

Site	Site Description	Time	Temp (C°)	DO SAT	DO (mg/L)	PH	Comments
TB1	East of 50 in woods	9:07 AM	19.7	91.0	7.7	7.8	heavy algae mats in SW pond
TB3	Next to Merrick Ln SW Pond	9:38 AM	19.5	90.0	7.6	7.9	thick algae mats in sw pond, moderate algae in stream
TB4	Rails to Trails	10:02 AM	19.9	85.0	7.0	8.0	
TB5	Easton Utilities	10:40 AM	19.8	88.0	7.2	8.0	

5 June 2012

Site	Site Description	Time	Temp (C°)	DO SAT	DO (mg/L)	PH	Comments
TB1	East of 50 in woods	9:37 AM	N/A	N/A	N/A	N/A	no flow in stream
TB3	Next to Merrick Ln SW Pond	9:45 AM	N/A	N/A	N/A	N/A	no flow in stream
TB4	Rails to Trails	10:07 AM	21.2	89.0	6.8	7.8	
TB5	Easton Utilities	10:38 AM	21.8	85.0	6.6	7.7	significant amounts of algae down stream of sampling site

28 June 2012

Site	Site Description	Time	Temp (C°)	DO SAT	DO (mg/L)	PH	Comments
TB1	East of 50 in woods	12:00 PM	N/A	N/A	N/A	N/A	no flow in stream
TB3	Next to Merrick Ln SW Pond	12:30 PM	N/A	N/A	N/A	N/A	no flow in stream
TB4	Rails to Trails	12:45 PM	N/A	N/A	N/A	N/A	Not enough water to sample
TB5	Easton Utilities	1:06 PM	26.0	67.0	5.5	8.2	heavy algae in stream, downstream of site
TB6	Pond 2	1:00 PM	25.8	135.0	11.0	8.3	thick filamentous algae
TB7	Pond 1	12:47 PM	24.6	90.0	7.5	8.1	thick algae mats

10 July 2012

Site	Site Description	Time	Temp (C°)	DO SAT	DO (mg/L)	PH	Comments
TB1	East of 50 in woods	9:50 AM	N/A	N/A	N/A	N/A	no flow in stream
TB3	Next to Merrick Ln SW Pond	10:10 AM	N/A	N/A	N/A	N/A	no flow in stream
TB4	Rails to Trails	10:15 AM	N/A	N/A	N/A	N/A	Not enough water to sample
TB5	Easton Utilities	10:37 AM	28.4	61.0	4.9	8.1	mats of algae in stream, downstream of site
TB6	Pond 2	11:03 AM	27.5	65.0	5.4	8.2	thick filamentous algae
TB7	Pond 1	11:15 AM	27.2	80.0	5.9	8.3	a lot of algae

10 October 2012

Site	Site Description	Time	Temp (C°)	DO SAT	DO (mg/L)	PH	Comments
TB1	East of 50 in woods	1:45 PM	N/A	N/A	N/A	N/A	no flow in stream
TB3	Next to Merrick Ln SW Pond	12:16 PM	15.0	79.0	7.9	7.0	Algae in stream, exposed to light
TB4	Rails to Trails	12:28 PM	14.2	70.6	7.1	6.9	Algae in stream, shaded from light
TB5	Easton Utilities	12:43 PM	18.3	119.0	11.2	7.3	Temperature increase due to stream going underground

10.6.4 Wet weather sampling

Date	Site	Rainfall (in.)	TN (mg/l)	TP (mg/l)	Flow (ft^3/s)
8/10/2012	TB 5	1.01	1.081	0.244	bankfull≈100
8/10/2012	TB 5(dup1)		1.257	0.27	
8/10/2012	TB 5(dup2)		1.231	0.28	
8/10/2012	TB 5(dup3)		1.057	0.195	
8/10/2012	AVG		1.156	0.247	100
9/18/2012	TB 5	0.94	0.791	0.211	30
9/18/2012	TB 5(dup1)		0.826	0.218	
9/18/2012	TB 5(dup2)		0.763	0.213	
9/18/2012	TB 5(dup3)		0.953	0.204	
9/18/2012	AVG		0.833	0.211	30
	Average		0.99	0.23	

10.6.5 Load Reduction Calculation

Cost per lb for each retrofit was calculated using subwatershed maps for each retrofit generated by the GIS Program at the Center for Environment and Society. Bioretentions were assumed to have 46% efficiency (CWP, 2007) and bioswales were assumed to have 59% efficiency at removing TN (Jurries, 2003; CWP, 2007). To estimate the annual load for each retrofit project the simple method for pollutant loads was used:

$$\mathbf{L = 0.226 * R * C * A}$$

where L= Annual load (lbs), R= Annual runoff (inches), C= Pollutant concentration (mg/L), A=Area (acres), 0.226= Unit conversion factor (Schueler, 1987). Pollutant concentration was assumed to be 2.2 mg/L TN.

Annual runoff from annual rainfall was estimated using:

$$\mathbf{R = P * Pj * Rv}$$

where R= Annual runoff (inches), P= Annual rainfall (inches), Pj= Fraction of annual rainfall events that produce runoff (usually 0.9), Rv= Runoff coefficient. The runoff coefficient was estimated assuming 100% imperviousness (Schueler,1987).

10.7 Brochure: Simple Ways You Can Help Save the Bay

1. Test your soil

Find out what level of nutrients your lawn already has and what it needs before you consider using fertilizers or chemicals. Many people apply fertilizer when the native soils already have all that they need to produce a beautiful lawn. Unfortunately, excess fertilizer doesn't stay on the lawn. It ends up running into the nearest tributary and into the bay contributing to health problems. The University of Maryland cooperative extension service has soil test kits available at a very low cost to help you maximize your investment in your lawn. Call 410-822-1244.

2. Fertilize only when and where necessary

After testing soil, use the recommended amounts of fertilizer needed. Be sure to keep it off of pavements, sidewalks and driveways. If fertilizer is needed, it is best to apply it once in the fall. Never use fertilizer for any other purposes such as de-icing.

3. Divert your rooftop runoff into a new rain garden or rain barrels

Pollution falls to the ground during rainstorms. You can reduce rainwater impact by making sure your downspouts do not discharge directly onto pavement. You can construct a beautiful garden that holds your stormwater before allowing it to drain into driveways, streets, or gutters, then ultimately into the bay. Rain barrels connected to your downspouts allow you to store rainwater and use it at a later time to water your garden or your yard. Rain barrels are available at www.cbtrust.org/site/c.miJPKXPCJnH/b.5458173/k.8975/Rain_Barrels

4. Leave grass clippings on the lawn

As an alternative to chemical fertilizers, leave grass clippings on your lawn to provide the soil with nutrients. This recycles the grass with very low maintenance.

5. Use compost as fertilizer

Another fertilizer alternative for the garden is a compost pile that reuses food waste, grass clippings, yard waste, and other natural ingredients to make a nutrient and mineral-rich compost that can be added to garden soil to increase productivity and health of the soil. You can also purchase compost in bags or in bulk from garden centers. Additional information on composting can be found at www.epa.gov/wastes/conserve/rrr/composting/

6. Mow the lawn at the proper height

Set your mower blade height to 3-inch and keep the blades sharp. Many people cut their grass too short, which never allows the grass to get ahead of the weeds or develop a strong root system. Strong roots are needed to get your lawn through drought. A general rule of thumb is to never cut more than one third of the grass blade. If you allow your lawn to grow longer it will shade out weeds and develop healthy roots system. Consider using a push mower in place of a motorized mower.

7. Reduce use of pesticides and herbicides by at least 50%

Pesticides and herbicides poison your yard's balanced ecosystem by killing the natural predators and native plants that would otherwise help your yard maintain its health. Take the time to monitor the natural systems in your yard.

Adopt a natural, integrated pest management strategy around your home that reduces or eliminates your use of chemicals. Only use, or have your lawn professional apply, chemicals when all other options have been exhausted. Even then take care to use the minimal amount needed. Alternatives to chemicals include using beneficial insects and attracting natural predators to your yard. Additional information can be found at www.beyondpesticides.org

8. Plant native trees and shrubs

A mix of native plants will decrease pests, disease, and weed problems as well as provide valuable food, shelter, and cover for wildlife. Ask your local nursery to provide you with a list of native trees and shrubs they offer or get advice from the cooperative extension service. Additional information can be found at mdflora.org

9. Provide wildlife habitat

Wildlife such as hummingbirds, hawks, fox and other birds and small mammals need a source of food, water, and shelter, particularly in urban and industrial areas where habitat has been lost. Plant trees and shrubs to provide a food source, especially in the winter. Consider also providing a water source.

10. Reduce your lawn size

How much lawn area do you really need? Assess your lawn use and reduce the grassy area to the minimal amount needed. Plant buffers of native trees, shrubs, and gardens in the remaining yard that will soak up excess nutrients and prevent soil erosion.

For information, please contact Midshore Riverkeeper Conservancy at 443-385-0511 or info@midshoreriverkeeper.org